THE 20th CENTURY
Toolsmith and Steelworker

ILLUSTRATED

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A COMPLETE, PRACTICAL, AND SCIENTIFIC BOOK, WRITTEN BY A THOROUGH EXPERT MECHANIC AND STEEL-WORKER, ESPECIALLY IN THE INTERESTS OF BLACKSMITHS, TOOLSMITHS, TOOL-MAKERS, AND ALL MECHANICS CONNECTED DIRECTLY OR IN-DIRECTLY WITH THE USE, REPAIR, AND MANU-FACTURE OF STEEL INTO TOOLS

FULLY ILLUSTRATED

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PREFACE

This book is written in the interests of all mechanics connected with the working and manufacture of steel into tools, and gives all the secrets and obstacles to be overcome towards making steelwork or toolmaking a success. It will be invaluable to the young mechanic and place him years in advance of his fellow workman, by the reading and a little reflection of its contents.

It is not comprised of quack theories or foolish ideas, and is not written by a college student, who knows nothing except what he has been told or gathered up from papers and periodicals. But is written by a thorough expert mechanic who has spent the best part of his life over the anvil with the hammer and tongs and making tools of every description, from steel of every quality and temper and almost every brand or make, and the contents of this book are the results of hard work, deep study, years of experimenting and wide travel. The information given is of a simple, practical, and scientific nature, which can be easily understood and everything accomplished by a mechanic of average intelligence.

It gives full and complete instructions with illustrations, how to forge, weld, anneal, harden and temper, every tool that the toolsmith or toolmaker is called upon to make or repair, and if the directions are followed closely, this book will be the means of lifting a great many out of a rut of darkness and place them on the road of sunshine to mechanical success, as this information could not be gained in a lifetime in the ordinary blacksmith shop or from the steel manufacturer.

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INTRODUCTION

In introducing this book to my readers and brother mechanics, it has long been my aim to bring this volume of information before the steelworkers and toolmakers in general and to present it in a clear simple way that the average mechanic will quite readily understand. Although there are other books written and published on this great subject of steelworking, the information which they contain is not expressed in a clear light that is beneficial to the ordinary reader, for unless the reader is already an expert steelworker the book is not easily understood without a great deal of thought and study, as some authors oppose their own ideas, others again do not take up the entire subject and the information which is most profitable to the young mechanic and also which is most impressive on his mind is left unwritten.

But this book which is entitled, The 20th Century Toolsmith and Steelworker, will give fully all the information and knowledge of working steel in a clear light so that the young mechanic or apprentice will readily improve, if he will but read. The methods given and used as regards the working of steel, are of the most modern, simple, practical, and scientific nature, while the instructions are from the experience of a successful steelworker of good reputation, and who has spent years in hard work, ranging in extent from the humble country blacksmith shop to the largest and best railroad, locomotive and machine shops, also stone yards, quarries and mines of North America, which is the only correct way of gathering together the vast amount of knowledge contained in these pages and which has cost the author thousands of dollars in wide travel and collecting valuable ideas from some of the greatest living mechanics and steelworkers that America has produced.

Although this book is chiefly intended for blacksmiths, toolsmiths and tooldressers, it will be found invaluable to every mechanic connected directly or indirectly with the repair and manufacture of steel into tools, and if the directions are followed closely, the amateur steelworker will become an expert of the highest degree, as there is nothing mentioned, but that which has been accomplished by the author and proven by experiment to be the greatest success.

This book is not merely written for the young mechanic or apprentice, but likewise for the old, and it does not signify if the reader has worked over the anvil for forty years, there is information that will help him overcome difficulties and obstacles connected with steel.

Although the instructions given are principally in reference to heating steel in the blacksmiths or open fire and which is mostly used, this book gives information concerning heating and tempering furnaces. But, it should be remembered that if a mechanic can work steel by heating it successfully in the open fire, he will experience very little trouble when heating steel in a furnace or lead bath as used in large and up-to-date toolshops and factories.

I wish to say to all mechanics young and old but more so to the young mechanics who have a desire to reach the top of the ladder and gain a good reputation, and especially to those who chance to get a copy of this book, that the greatest obstacle they have to contend with when trying to improve, is to change from the rut they have already fallen into, chiefly made by themselves and the teachings of their first masters. I state this from experience, and to illustrate fully after I learnt my trade (or "served my time," is a more reasonable way of explaining), having plenty of confidence and a great share of conceit in my abilities, I started out as a journeyman blacksmith, "and then" I found out I had something to learn. But I found out that to change my ways and ideas was quite a difficult task and often got me in hot water, as I thought my way or rather the way I was learnt from my first boss was correct. However, I soon decided that if I wanted to climb to the top of mechanical success and have a good reputation, I would have to change my ideas if I thought some other shop mate had an idea or method that was superior to mine, keep my eyes open, and do a great deal of thinking in my "own" mind.

And if I could have had this book at the close of my apprenticeship, it would have saved me many a troublesome job, many a long hour of study, a great deal of experimenting, large sums of money and placed me years in advance of the present times. And so I wish to say to the reader, although he may have some good ideas that perhaps are equal to the author's, while on the other hand he may have some not as good, read this book carefully from beginning to end, and follow its advice and he will be crowned with success, as a poor mechanic or Jack of all trades is not wanted in these days, where there is as much competition for the mechanic's job as there is between business men in any mercantile business. And again, I say to the mechanic read this book carefully, follow the instructions closely, and you will hold your job and take first place.

CHAPTER I.

Steel, its use and necessity—Composition—Successful treatment—Different kinds—The cracking of steel when hardening and the cause—Judging and testing.

Steel, Its Use and Necessity in All Arts, Trades and Professions.

We could get along without a great many other materials and metals, "but we must have steel," its great necessity comes first in all arts, trades, and professions. The doctor or surgeon must have fine lancing knives the dentist must have forceps, and the sculptor must have fine chisels. The machinist, boilermaker, stonecutter, bricklayer and the stone mason, must have their tools made from steel in order to perform their skillful labor, likewise, the king and foundation of all mechanics, "The Blacksmith," he must in the first place have the anvil, hammers, chisels, fullers, swages, etc., to do his own work and make tools for others.

Our capitols, government buildings, palaces, cathedrals, the great railroad systems, likewise the defense of our country, the navy and its guns, are all brought to the stage of perfection, by the use of steel and so we can readily see that steel comes first and foremost of all metals, and the mechanic who is so fortunate as to become a good steelworker, is entitled to all honor and should be proud of his skill.

The Composition of Cast Tool Steel.

In order to understand this subject fully, it is necessary to know something pertaining to the manufacture. But in a simple way of explaining, cast tool steel is chiefly composed of bar or wrought iron, although wrought iron is a very useful metal, it is of too soft a nature in its natural state for the purpose of tool making. Consequently iron is put through a process by the steel manufacturer, and by the use of charcoal the iron becomes carbonized and so converted into steel.

A great deal could be written on the manufacture of cast tool steel, as the steel, after being manufactured may be of good or bad quality and also being of different degrees of hardness or temper. The quality of the steel depends on the quality of iron used in the manufacture, while the hardness of the steel depends on the amount of carbon it contains. The temper of steel is classed or measured by the percentage of carbon in the steel, for example 100 points is equal to 1 per cent, to further explain, steel that is right for making cold chisels will consist of 75 points carbon, while steel used for machinists' lathe or turning tools which is required to be much harder will consist of 1 per cent.

Good cast steel should be manufactured from pure Swedish iron and should contain not less than 60 points carbon in order that it will readily become (after passing through the various processes of the steelworker) hard as glass, tough as whalebone and as soft as lead. When toolmaking, a good quality of steel should always be used, but as to hardness, it will depend on how the tool is to be used and what material the tool is to cut or be used upon, also a great deal will depend on the skill of the steelworker.

The Successful Treatment of Steel.

In the successful treatment of steel lies the foundation of this book and the toolsmith's art, and with which all the following processes that the steel must pass through before reaching the finished tool are connected. Thus: heating, forging, hammering, hardening, quenching, tempering, welding and annealing. These processes all form an equally important part in the manufacture of tools, and so to become an expert steelworker this subject must be understood by having a thorough knowledge regarding the nature of steel, together with good judgment, carefulness and skill.

Heating.

There are a great many different ways of heating steel, although the most common way is in the blacksmith's coal or open fire, but in the large shops where tools are made in great quantities may be found furnaces especially adapted for tool making which are heated by oil, gas, etc.

The heating of steel is somewhat complicated owing to the different temperatures that are required (reader, give this your particular attention as success depends on the following), heating may be divided into four classes, as the forging heat, the hardening heat, the annealing heat and the welding heat. But for the benefit of the apprentice, I will say the different heats must be learnt by experimenting, but to the blacksmith of more or less experience, I will describe the heats of a piece of ordinary steel 75 points in carbon (which will answer all ordinary purposes), in the following manner; a yellow heat for forging, cherry red for hardening, blood red for annealing, and a white heat for welding.

Forging.

Forging is the toolsmith's labor which is required to bring or change a piece of steel into any shape or form, by referring to the forging heat, it is at all times necessary and beneficial to have a yellow or soft heat, then the steel will be worked clear through, and especially in heavy forging, but the heat must gradually decrease as the tool becomes finished. For example, supposing the toolsmith has a piece of steel one inch square and it is to be forged down to a chisel shaped point, it is heated slowly and evenly to a high or yellow heat, the toolsmith and helper forges it into the shape required until it is necessary to get another heat, but the second heat will not necessarily be so hot as it will be sufficient to finish the tool and the hardest work is over, when the steel is finished at a low heat and the last blows of the hammer fall on the flat side. The steel is left finer and stronger than if finished at a high heat.

Hammering.

Hammering steel in the finishing stage is one of the greatest secrets of success connected with forging tools, it is at all times necessary as it toughens, refines and packs the steel, but it is chiefly for tools that have a flat surface. On tools that have no flat surface but are either round or square, the blows must naturally fall on all sides alike, consequently the steel is left in its natural state. But tools that are flat, such as cold chisels or mill picks, the last blows say 10 or 15, must fall on both flat sides evenly when at a low heat, but bear in mind that not a blow is to strike the edge as it will knock out all the tenacity that has been put in the steel by the blows on the flat surface, and do not hammer the steel too cold as it will ruin the steel. If the hammering is properly done the steel will show a bright black gloss.

Hardening.

The process for hardening is by heating the steel to a certain heat then cooling off suddenly in water, which will immediately change the steel from its soft natural state, into that of a hard glasslike state and will show a white appearance when coming out of the water. But after coming through this operation the steel may be properly or improperly hardened, steel that is properly hardened is finer and stronger than improperly hardened steel, and if broken would present a fine crystalized fracture, while on the other hand, improperly hardened steel when broken would present a coarse fracture resembling a piece of honeycomb and will break very easy. The secret of success for proper hardening lies in the heat that is used, the proper heat must be found out by experimenting. A good way to find out the proper heat, will be, take a small piece of steel and on one end put deep nicks in it with a chisel, about half an inch apart, say, for three inches back, as shown in Figure 1. Now place the end that has the nicks, in the fire and heat the extreme point to a white or welding heat, then plunge into cold water and cool off "dead cold." Now place over the anvil, commencing at the extreme point that was the hottest and break off at the first nick, then the next and so on until all is broken, and the results will be as formerly explained. The first piece when broken will show a coarse, hard and very brittle fracture being very easy to break, and as the other pieces are broken the fracture will be noticed to be getting finer and harder to break until the

Fig. 1. Showing piece of steel for hardening test.

one is come to showing a fine crystallized fracture resembling a piece of glass. Another way to find out the proper heat for hardening will be to have 3 or 4 thin flat pieces of steel, heat them to different heats then break off taking particular notice of the fracture, and how some pieces will break much easier than others.

When hardening steel, always bear in mind to harden it at as low a heat as it will be sure to harden at, as proper hardening is the gateway of success in making tools that have to hold a good cutting edge.

The Hardening Bath.

In connection with the hardening of steel the hardening bath forms a very important part and which should not be overlooked. It consists chiefly of water, which must be clean and free from all oily or greasy substance. Water containing any greasy substance of any kind will not act so quickly or as satisfactory as clear, clean water. Rain or soft water is preferred to hard well water, but salt put in the water to form a brine is still better, as steel will harden at a lower heat in brine than in the ordinary pure water and this is a point to be well considered, so keep as much salt in the water as it will dissolve or soak up. Still another advantage by the use of brine is that it will not steam up so quickly as water and this is also worthy of thought when hardening large tools. At all times keep the bath as large and as cold as possible.

Quenching.

In the quenching or cooling of steel during the hardening process, a great deal is to be learned, as sometimes the tool is liable to warp when being quenched, in some cases so bad as to spoil or crack the tool, while the cause will occur from improper quenching, as a great deal depends according to the way the tool is placed in the water or hardening bath, and also according to the shape of the tool.

Some tools must cut the water as a knife, others again must thrust it as a dagger, and some at one angle, some at another. For example, take a round piece of steel 6 inches long and ¾ thick, and it is to be hardened the whole length of itself. After heating, it will have to be lowered into the bath from a perfectly upright position, if it has been properly forged, heated, and annealed, it will come from the water perfectly straight, but should it be placed in the water from an angular position it will be very apt to warp. Wide flat tools, whether partly or wholly hardened should be quenched in a perfectly upright position or they will warp flatwise.

Tempering.

After hardening the steel it will be too hard for some purposes, and so the hardness must be reduced by reheating it to a certain degree according to the work it is to do, which is "termed" tempering. If a piece of hardened steel be polished bright, then reheated, different colors will appear and change as the steel becomes heated to a greater degree. The colors will appear in their turn as follows, commencing with the least degree of heat will be a light straw, dark straw, copper, red, purple, dark blue, light blue and grey, and by watching the colors the steelworker regulates the temper or hardness of the tool.

Tempering is the process that will readily change steel from its hardened glass like state into an elastic springy nature resembling whalebone. For illustration, take a thin piece of steel 3 inches long, ½ inch wide, 1-16 thick, after hardening the whole piece from end to end then tempering to a very light blue and allowing it to cool off on its own accord, it will be found to be in a very elastic state and if bent it would immediately come back straight again. Tempering should not be classed as hardening or vice versa, as is often the case with a great many mechanics. For example, a tool that is to be only hardened and no temper drawn, should be classed as hardened, "and not tempered."

Welding.

Welding is the process or art of joining two pieces of steel together so as to form one solid piece, and which forms a very important part in steel working or toolmaking. There are several errors made when welding steel, some of the most common ones being, the want of the proper knowledge concerning the nature of steel, a green or unclean fire containing sulphur and other foreign matter, which is dangerous to hot steel, the absence of the proper welding heat, and improper ways of uniting the pieces together. For the benefit of those who have not had much practice and those who have only been partly successful, I will give these instructions, which, if followed closely will insure success. First of all the welding point in the steel that is to be welded must be known, as there are several kinds of steel, some will require a higher heat to weld than others, the heat varying according to the hardness of the steel.

For illustration, we make a weld by uniting two pieces of steel together and we have had good success, as the weld represents one solid piece. Now we proceed to make another weld, and in exactly the same way as the first weld, the same welding heat is used and the same fire, but this time we do not meet with success for as soon as the hot steel is struck with the hammer, to form the weld, the steel flies to pieces (I hear the reader ask the reason, why), because the steel was heated to a higher heat than what the steel would stand, and the consequence is, all the labor has been lost, the fault lies in not knowing the welding point.

We could take wrought iron and make every weld at the same heat, but not so with steel, on account of it varying in hardness. And so in cases when the mechanic is in doubt as to the hardness or welding point in the steel, use this rule. Take a piece of the steel that is to be welded, heat it to a yellow heat, then place it over the edge of the anvil and strike it a light blow with the hammer, if the steel does not crumble or fall to pieces, keep increasing the heat until it does, this will enable anyone to test the steel for hardness, and so find the welding point or just how high a heat the steel will stand before crumbling or flying to pieces when making a weld.

But although the welding heat is well understood, there are other things to consider, as we must have a clean fire with the coal well charred and all gas, sulphur, clinkers, ashes, etc., must be taken from the fire, to insure a solid weld. Welding is more fully explained in another chapter of the book, as, in dirt picks.

Annealing.

The chief object of annealing steel is to soften it, the process being almost opposite to that of hardening. In hardening, the steel is cooled off very quickly, but in annealing, the steel is cooled very slowly. Steel to anneal must be heated in somewhat the same manner as to harden, with the exception that the annealing heat must not exceed the proper hardening heat, a little less heat will be best, for example a blood red.

The advantage to be gained by annealing steel is to make it soft, in order that it may be easily filed, turned, or planed. Without annealing some steel will be too hard for the machinist's use, tools that are forged by the toolsmith and finished by a machinist should always be annealed, and in a great many cases the steel must be annealed when it comes from the manufacturer, before it can be worked satisfactorily.

There are many ways to anneal, but the method that is commonly used, is by taking a piece of steel heated to the heat previously mentioned, and packed deep into slack lime allowing it to remain there until perfectly cold. Wood ashes may be used in place of slack lime, but they should be perfectly dry and free from all dampness. Fine dry sawdust is also very good, but it should be kept in an iron box in case the sawdust catches fire.

There is another good way to anneal and which is very often preferred on account that it is much quicker. Take a piece of steel heated as mentioned. Then hold it in a dark place long enough, so that the heat will all pass off, save a dim dull red. Then plunge into water to cool off. This is called the water anneal, and some machinists say that tools take a better hold of it. If the process was right the steel will come from the water resembling a piece of hardened steel, showing a black and white appearance by being partly scaled off. This method, however, may need a little experimenting before getting the best results. Points on annealing will be found in other parts of the book.

Different Kinds of Steel.

There are many kinds, grades, and brands of steel which vary in shape, quality, and hardness, according to the tool that is to be made from it and which the ordinary blacksmith is not familiar with. Steel used in the blacksmith shop does not take in such a wide range as that used in a large machine shop, as steel of 75 points carbon will answer all purposes in the blacksmith shop, but in the machine shop steel is used of a much higher carbon, ranging up to 100 points or 1 per cent and even higher. High carbon steel is used chiefly for making lathe and planer tools, which has been found out by practical experience to be preferable owing greatly to the reason, that these tools do their work by steady pressure. Should a cold chisel be made from high carbon steel, say 1 per cent, the head of the chisel would be continually breaking and splitting off. High carbon steel is more difficult to weld and will harden at a less heat than low carbon steel. Tools that are to do their work by striking with a hammer, as a cold chisel, should always be made from a medium low carbon steel. But in these days, steel can be had in any shape or temper to suit any tool, so when ordering steel from the manufacturer always state what kind of tools the steel is to be used for. The percentage of carbon which the steel should contain for different tools will be fully explained throughout the book, as each tool is described.

The Cracking of Tools When Hardening and the Cause.

The cracking of tools during the hardening process, is one of the great obstacles to be overcome by the steelworker, and which is the cause of the loss of a great amount of expensive tools and labor.

The primary and main cause for tools cracking when hardening, is overheating of the steel, another cause is by uneven heating, still another cause will result from forging and leaving strains in the steel by irregular heating and hammering, and also by improper annealing. Steel that is heated in the blacksmith's fire is very liable to crack in hardening, unless great care be exercised, and the tendency for the steel to crack will be increased, if the mechanic has only a limited amount of knowledge as regards the nature and virtue of steel. For illustration I will give the way that a great many who call themselves steelworkers, harden a piece of steel. They will take the piece of steel, place it in the fire, then turn on or blow a very strong blast so as to heat it quickly, getting one part at a white heat while another part is barely red, then plunge it into the water any way to cool off, consequently it cracks, and the operator blames the steel saying it was no good, while he himself was to blame. Laying the blame on the steel is the theory of a great many blacksmiths and steelworkers, especially when the tool does not give good satisfaction. But on the other hand, should the tool do good work they are ready to take all the praise to themselves by telling others about it, and I state this from experience as I have been in the same position before finding out my mistake.

Now let us harden a piece of steel properly as it should be done, and for example, supposing we have a flat piece to be hardened, 2 inches square by ½ inch thick. Place the steel flatways on top of the fire, heat slowly and very evenly, turning the steel over occasionally so as not to heat in streaks, until the whole piece becomes heated to a cherry red or just enough to harden, then cool edgeways from an upright position, in clean cold water allowing it to remain there until it is perfectly cold, and it will be perfectly hardened and free from all cracks.

And to more fully illustrate, I will relate a little incident in my own experience. I took a position as toolsmith in one of the large shops of the Chicago, Rock Island and Pacific Railroad. The first job I undertook to do, was to harden and temper a great number of flat thread cutting dies, as I started to work the machinist foreman came along and said to me, "I want you to harden these dies without leaving cracks in them." A few days after the dies had been in use, I asked him if he found any cracks in the dies, and he replied "no, not one." Then he went on and explained to me, that the toolsmith who was there before me, was continually leaving cracks in the dies and laying the blame on the steel saying it was no good, while the dies were not giving good satisfaction and at the same time keeping a machinist busy making new ones and keeping others in repair. A few days later the machinist (who was keeping the tools in repair) came along to me and said, "I am not working much more than half my time since you started, as I have not near so many dies to keep in repair." Reader, I have not related this affair to give myself praise, but instead, to point out to you the difference between two mechanics and both calling themselves toolsmiths, one having very little knowledge concerning the nature and working of steel, was giving poor satisfaction, spoiling a great many tools and resulting in the loss of his position.

The other had a thorough knowledge of steel in every way and did his work in a highly satisfactory manner.

The first man did his work by heating his tools too fast, having one part of a tool at a white heat and another part scarcely red, and when being cooled to harden they cracked. The second man did his work by watching carefully so as to heat the tool very evenly, no part of the tool being any hotter than just enough to harden, the results being every tool came through the hardening process safe and sound, without a flaw of any kind. Reader, which of these mechanics are you going to be, first or second? Consider the difference between the two, then take your choice.

How to Judge Hard from Soft Steel.

There are numerous ways of telling the difference between hard and soft steel, as in the following. First way is by the fracture of a fresh break, as hard steel when broken cold from the bar, will show a very fine and smooth fracture, while soft steel will show a coarse and rough fracture. Second way, take two bars of ¾ inch octagon steel nick the bars all around when cold, 6 inches apart for cold chisels, place the part of the bar at the nick directly over the square hole of the anvil. Then strike with a sledge. The hard bar will break at the nicks with one or perhaps two blows, but the soft bar will require five or six blows in order to break it.

Third way, supposing a number of cold chisels are to be dressed that have been in use for some time, by close observation it will be seen that the heads are of a different shape and appearance. For instance. The head of one chisel will have the steel widened out and curled down over the body of the chisel. This illustrates soft steel of about 60 points carbon. Another head will crumble off as it widens out instead of curling up. This indicates steel of medium hardness of 75 or 80 points carbon, which is the best for cold chisels and all similar tools. Still another head will show the steel split and broken off half an inch down the sides. This represents a high carbon steel of 1 per cent, which is too hard for chisel use, but would be good for lathe and planer tools. This way is perfectly reliable when telling the difference between hard and soft steel. When forging, soft steel will give much more readily under the hammer and will hold the heat much longer, than hard steel.

If two pieces of steel, one hard the other soft, are hardened at the same heat, the hard piece will be scaled off white, while the soft piece will be only partly scaled off, showing a black and white appearance.

How to Tell Good from Poor Steel.

The fracture of good steel when first broken, will show a silvery white appearance clear through the bar, while the fracture of poor steel will show a dull grey. When judging or testing steel by the fracture do not allow the steel to get wet or rusty.

Testing Steel After Hardening With a File.

When hardening tools of an expensive nature, it is always best to make sure the steel is properly hardened before undertaking to draw the temper, by testing with a good sharp file in some part that will not interfere with the cutting qualities of the tool. Should the file run over the steel without taking a hold, the steel is all right, but on the other hand, should the file take a hold of it, the tool will have to be hardened again, having a little higher heat than the first time.

Instructions on Toolmaking That Have to Be Given Many Times.

In giving instructions on toolmaking in the following chapters of this book it will be necessary to give to a certain extent the same advice as different tools are described. And so I will ask the reader to bear this in mind, as what is told many times will be that which is most beneficial towards making steel work a success, and also which I wish to impress most deeply on the reader's mind in order that it may be well remembered.

CHAPTER II.

The blacksmith's fire — Anvil—Tongs—Making a hand hammer.

The Blacksmith's Fire.

The fire is one of the most important things connected with the blacksmith's or tooldresser's trade, and is the first thing I will describe toward toolmaking. The main points of a fire to be considered is, the fire should be on a forge large enough to enable the fire to be easily regulated to any size, according to the work that has to be heated in it, and have plenty of blast which can be well regulated. The fire should always consist of well charred coal, being perfectly free from all sulphur, gas, ashes, clinkers and thick smoke before undertaking to heat steel in it.

In reference to the size of the fire I will illustrate, supposing we have a large piece of steel to heat (say a stone hammer), we want to heat it evenly and clear through, the fire must be large enough to accommodate the hammer so that it will not come in contact with the blast from the blower or bellows, and still have a certain amount of fire over the hammer, which will require a fire of about 6 inches deep and 8 inches across the surface, but a smaller fire will do in case of small tools.

The author has used a fire that was barely 1½ inches across the whole heated surface, but this was made especially for hardening and tempering certain parts of tools. But be on the safe side by having the fire large enough, as coal is cheaper than steel and saves time.

It will be money saved by securing as good coal as is possible to get, there being a great difference in coal, as some kinds are more free from smoke and sulphur and will not cake or get hard as othei kinds, and tools of irregular shape can be placed more easily without disturbing the build of the fire. Keep the coal under cover and clear from all rubbish, coal loses a great amount of its heating qualities when the sun shines on it continually.

Bellows and Blowers.

In the majority of ordinary shops the bellows are still used, some being much better than others, both as to the power of the blast and the construction of the bellows, and to anyone who is following the trade of blacksmithing I would advise having as good a one as is possible to get.

I have seen bellows that have been in use for fifteen years and are almost as good as new, while others will wear out in one year. The hardness or easiness as the case may be of blowing the bellows is chiefly due to the way they are set up (as I have seen bellows that would tire a blacksmith to blow them, which should be in the nature of a rest instead of hard work), and if the uprights or posts on which the bellows hang are in a very upright position, the chances are the bellows will be hard to blow, so set them at an angle of about 45 degrees. If the uprights are given too much angle there will be too much leverage, and the bellows will lack motion.

Blowers are used a great deal in these days (they take the place of bellows), which are run by hand in small shops by the use of a crank or lever, although in large shops blowers are run by steam power, and the smith simply regulates his fire by moving a lever to different positions. It makes no difference what produces the blast so long as there is plenty of it, and at the same time it can be well regulated.

The Anvil.

The anvil is a tool used in the blacksmith trade or shop which is practically the foundation of all tools, for the forging and shaping of all classes of work and more particular in regards to toolmaking. There are a great many different sizes of anvils, as well as a great many different makes. In reference to the size of the anvil, some smiths want one size, some another, but for general tool work an anvil weighing 225 pounds is about right.

There is a great difference in the make and also the quality of anvils. The author has forged tools on almost every make of anvil manufactured in Great Britain or the United States, but the kind that has given the most satisfactory results, and which can be relied upon, is known as the Hay Budden. Manufactured by the Hay Budden Manufacturing Company, Brooklyn, New York, U. S. A.

This make of anvils is fully guaranteed, they are made from the very best material and by expert workmen, and the face is perfectly hardened. There are no soft spots, neither do they sag down or get hollowing in the face, as in a great many other makes, including the Peter Wright. This is no hearsay, neither is the author favoring any particular manufacturer, but this advice is founded on experience which is for the reader's benefit, as in order to do good work a good anvil is necessary, which is perfectly free from all hollows and soft spots. Tools of a flat surface, such as cold chisels, mill picks, axes, etc., must be dressed on a hard and smooth anvil face to obtain the best results. When dressing wide tools such as an axe, a rough faced anvil will produce strains in the steel, which will increase the tendency to crack when hardening.

The height of the anvil when on the block depends upon the tallness of the blacksmith who is to forge on it. I have noticed cases where a blacksmith was working over an anvil so high as to be unable to strike a good hard blow, while on the other hand a tall blacksmith was working over a low anvil that was making him humpbacked and round shouldered. But a good rule to go by, which will be found about right for all, is to have the anvil just high enough so that the blacksmith may readily touch the anvil face with his knuckles when clasping the hammer handle and standing in an upright position.

Don't have the anvil merely sitting on a block that is continually jumping up and down with every blow from the hammer, but have it well bound to the block. But some will say, "That stops it from ringing," or "I can't work on an anvil that does not ring." Reader, this is all nonsense, what has the ringing of the anvil to do with the work, it may be all right for the class that wants to make a lot of noise to let others know they are working, but it is of no use when it comes to doing the work with ease, both for the blacksmith and helper. So have a block a little larger than the base of the anvil, a good depth in the ground, say 3½ or 4 feet (if it can't be made solid any other way), place the anvil on it and bore a hole through the block 6 inches below the anvil.

Now make a bolt from ⅝ round iron 2½ inches longer than the block, as shown in Figure 2 at **a**. Make

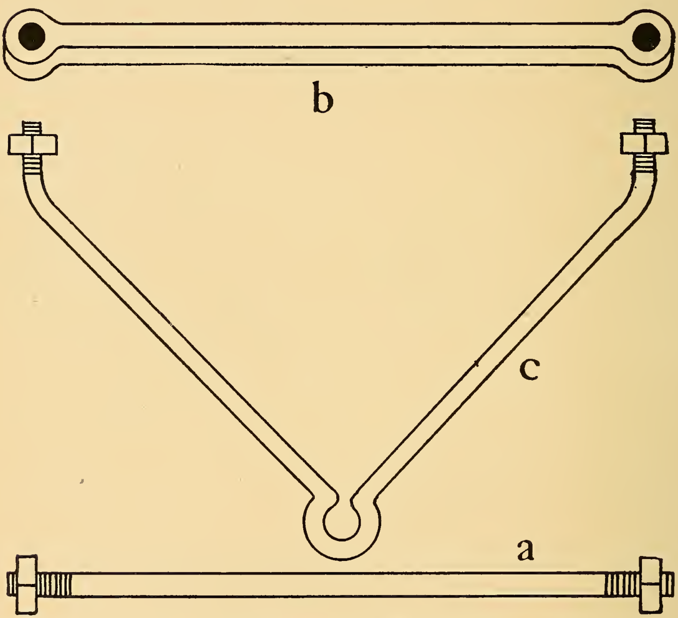


Fig. 2. Irons to bind anvil to block.

two irons from ⅝ square as **b**, leaving them long enough so that the holes in the ends will extend over the base of the anvil. After taking the measure make two irons, as **c**, which are to extend from below the bolt in the post up through the irons that rest on the base of the anvil **b**. Place all together and tighten up the nuts firmly. Figure 3 illustrates the anvil fastened to the block. In large up to date shops cast iron blocks are used, which are made especially for the anvil to fit into, thereby holding the anvil perfectly fast.

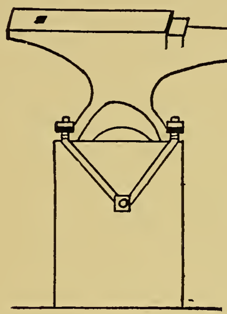


Fig. 3. Showing anvil bound to block.

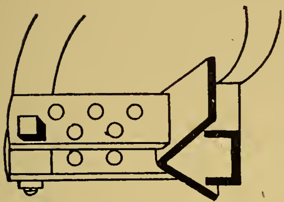
Tongs.

Tongs are among the most necessary tools needed by the blacksmith, and without them he would be at a standstill. There are a great many different shapes and forms of tongs (with the exception of a few ordinary styles) which are made according to the work they are to hold, and to be a good tong maker is an art to be proud of, as it requires skill to make them light and strong, and have them hold perfectly fast to the work without hurting or cramping the hand.

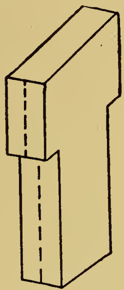
Success often depends on good tongs, as I have known blacksmiths to fail at their work simply for the want of them. Again, a blacksmith who uses all his strength to hold clumsy or poor tongs on the work cannot use his hammer to advantage. The author has tongs that are made entirely from steel and are very strong, and also are only half the weight of the ordinary iron tongs. They are a pleasure to use, as they hold perfectly firm with very little hard pressure, because the handles just come close enough together so as to keep the hand full, in somewhat the same way as clasping a hammer handle. These tongs have been in use a number of years and are as good as new.

In using tongs made from steel care should be exercised to keep them cool (and especially if made from cast steel) by occasionally placing them in water. If brine is used to do the hardening keep the tongs out of it or they will rust, but should there be occasion to put the tongs in it be sure and rinse off after in clear water.

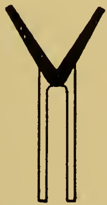
One of the greatest features in making tongs at the present time is to have them adjustable, so that one pair will do the work of seven or eight ordinary pairs of tongs. I have tongs in my possession that will hold from ½ inch square up to 1½ inches square, or octagon, and will also hold flat sizes 2 inches by ⅝ down to ½ square, and hold each size very firm, while the size is regulated by an adjustable jaw by moving a small bolt into different holes in the jaw, which requires but a few seconds to change, as shown in Figure 4. Still another point worthy of mention is to make the handles half round. This will form a spring and will be very easy to hold, but have the half round as wide as is reasonable; for example, ⅝ half round will be right and fill the hand better than 7-16 round. Figure 5 illustrates tongs specially adapted for dressing cold chisels, made with V-shaped jaws, which will readily hold round, square or octagon. When making tongs, as Figures 4 and 5, from cast steel use a very soft steel of about 60 points carbon, and ⅞ square in size. After forging the jaws, as shown in Figure 5, the handles may be



End view of adjustable tongs when holding smallest size.



Showing how adjustable jaw is forged—dotted lines indicate where to split.



Showing piece split and forged to shape of jaw.

Fig. 4. Adjustable tongs regulated for holding largest size.

Figure showing jaws made to hold round octagon or square.

Illustrating how jaws are forged and bent to shape.

Fig. 5. Tongs specially made for dressing old chisels and all similar tools.

forged or welded on, but will prove most satisfactory if forged in one piece.

Figure 6 illustrates double levered and adjustable tongs invented by the celebrated steel worker, Prof. W. S. Casterlin, Pittston, Pennsylvania, U. S. A. These tongs have been improved by the author and are very powerful and light. They are especially designed for grasping tools of a beveled nature, such as mill picks, axes, etc., and will hold flat material of any width, ranging in thickness from 1-16 to 1¾ inches. The jaws of these tongs are copper lined, which prevents slipping.

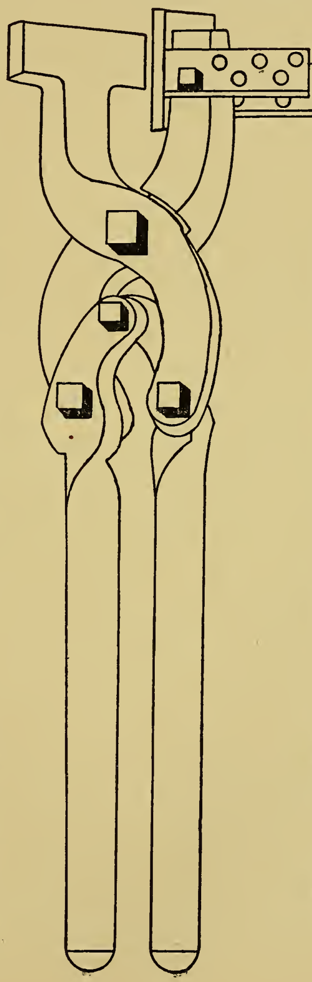


Fig. 6. Double levered adjustable tongs for dressing mill picks, axes, and all tools of a flat and beveled nature.

Fullers and Swages.

These tools are invaluable to the blacksmith in shaping and forging many classes of work, especially in toolmaking. Fullers and swages take in a wide range of different sizes, from ¼ to 2 inches for ordinary use, and larger sizes are used according to the class of work to be done. When making fullers or swages use a soft carbon steel of about 65 points. They will not require to be hardened or tempered as their work is chiefly on hot iron or steel.

Figure 6½ represents a top and bottom swage, while

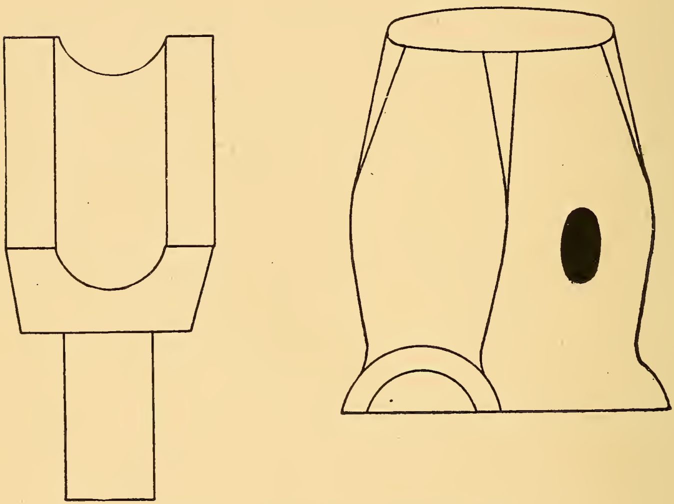


Fig. 6½. Top and bottom swages.

Figure 7 shows a small size of top and bottom fullers. Figure 8 illustrates a large top fuller. Figure 9 indicates how large swages, and also large fullers, as Figure 8, may be forged before bending to shape. Dotted lines as **aa**, illustrate the projections, **cc**, bent to form a fuller. Dotted lines, as **bb**, illustrates the projections bent to form a swage.

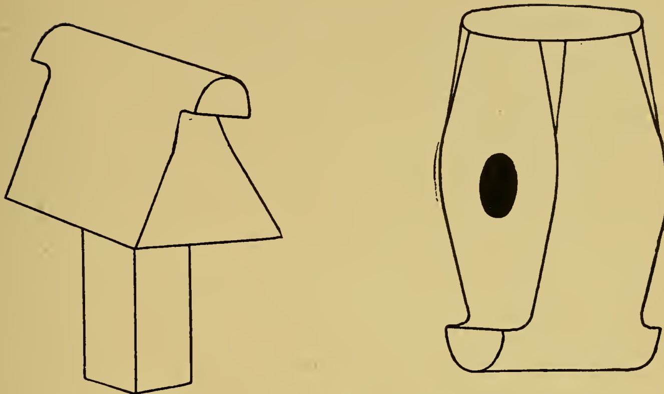


Fig. 7. Top and bottom fullers.

Fig. 8. Front view of large top fuller.

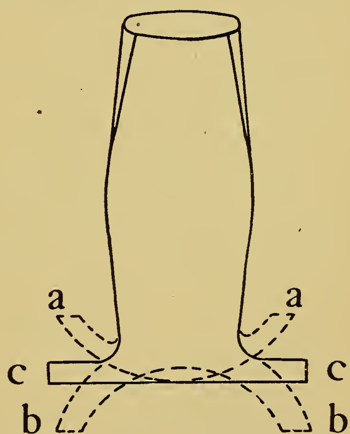


Fig. 9. How large fullers and swages may be forged.

Flatters and Set Hammer.

The flatter is to the blacksmith what the plane is to the carpenter, being principally used for taking out all hammer marks and so leave a finished appearance on the work, but may be used for several other purposes. Flatters may be divided into two classes, such as light and heavy (most blacksmiths make use of only one flatter, which is generally a heavy one, but a light one can be used to advantage in a great many cases), and although they are made with either round or square edges, the round edged flatter is preferred for general use. Flatters are generally made by upsetting the steel to form the face, then the projections of the face are spread with a fuller or otherwise may be driven down in a square socket, same size as the body of the steel. But flatters may be made by selecting a piece of steel the same size as the face of the flatter is to be, then fuller in from all four sides of the steel and draw out, afterwards cutting off from the main body of the steel according to the thickness or depth of the face.

Set hammers are very useful in making square corners and are very convenient in accomplishing work in awkward places which cannot be done with a flatter. Figure 10 illustrates a light round edged flatter, while Figure 11 shows a heavy flatter with square edges, and Figure 12 shows a set hammer.

The Hammer.

A good hammer is a tool to be prized by a blacksmith, and plays an important part in working steel. The face of the hammer must be properly hardened and tempered, in order to prevent it from getting hollow in the center or being too hard on the corners, thus causing it to break, and the face must be perfectly smooth so as not to leave any nicks or dents in the steel.

A great many blacksmiths think all they have to do

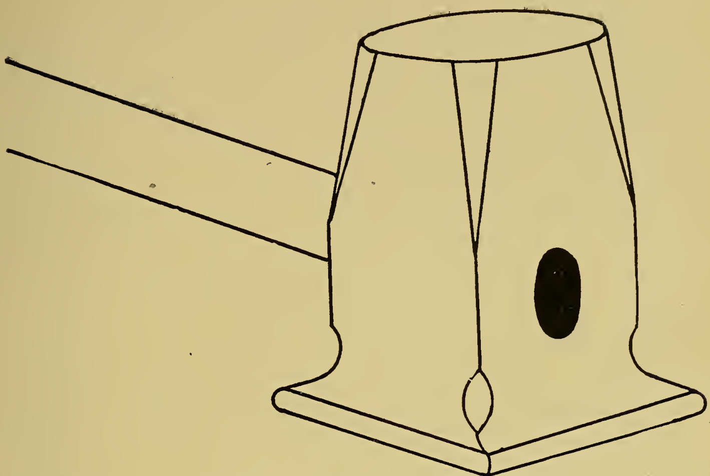


Fig. 10. Light round edge flatter, made from 1¼ inch square steel, face 2 inches square.

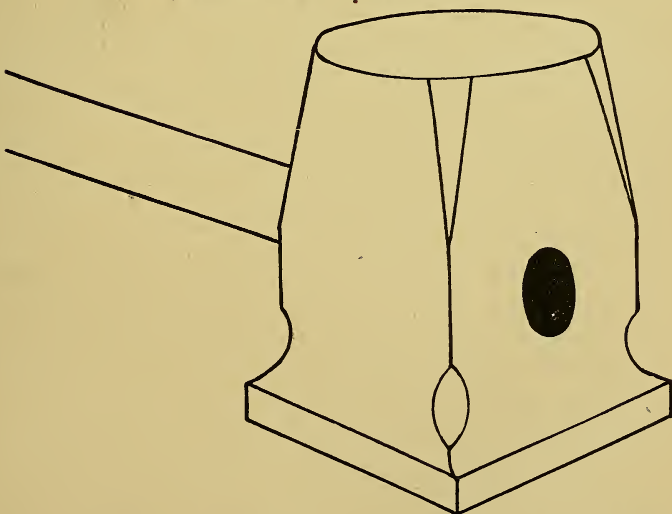


Fig. 11. Heavy square edge flatter made from 1½ inch square steel, face 2¾ inch square.

in order to get a good hammer is to go to the hardware store and buy one. They will buy one all right, but what are the results. It is this, after they are in use a little while a piece will break off the face, which if examined closely the fracture will show a dull gray appearance, a sure sign of poor steel.

By referring to buying hammers in the hardware store, I had a wide experience during my first years

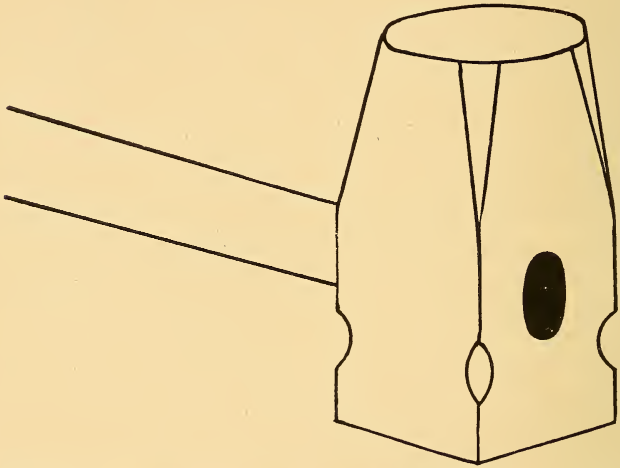


Fig. 12. Set hammer made from 1¼ inch square steel.

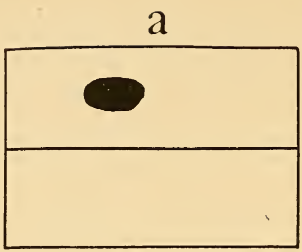
at the trade, and through ignorance, after purchasing a hammer and it did not give good satisfaction, I would generally give the hardware man a calling down for selling it to me. Although he was not to blame as his business was to sell and not to manufacture, and as regards his knowledge concerning good or bad steel, it was very limited. I am not stating this, reader, to criticise the hardware merchant, or the tool manufacturer, or machine made tools of any kind, as in a great many cases the machine tools are equal to those that are hand made. But not so in the case of a good hand forged, hardened and tempered hammer.

Making and Dressing a Hand Hammer.

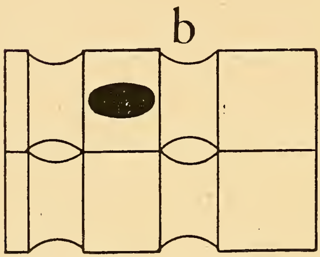
In making a hammer, as to weight and shape, it is hard to say what would suit all blacksmiths, but for a forging hammer for making and dressing tools, two pounds in weight will be about right. But in cases such as dressing mill picks, granite tool sharpening, and on jobs of tool dressing where a helper is not necessary, a hammer of three and one-quarter pounds in weight will be best.

But let us take a piece of good steel of about 75 point carbon, 1½ inches square and 4 inches long, which will make a forging hammer two pounds in weight. Have a good clean fire and plenty large enough; place the steel in the fire and heat slowly, turning it around occasionally so as not to overheat the corners while the center is yet black, but heat to a good even yellow heat clear through. The hammer may now be forged as shown and illustrated in **a b c**, Figure 13, or any shape the blacksmith may choose. I have known blacksmiths who could forge a well shaped hammer equal to the expert toolsmith, but when they came to the hardening and tempering of it would fail entirely.

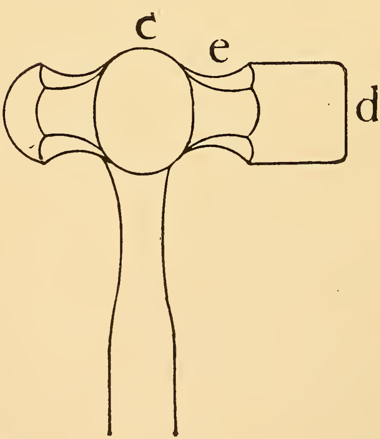
I will state some of the obstacles that blacksmiths have to contend with which reduce the chances of making a good hammer. They are afraid to heat the steel to a high forging heat; and to explain, I remember when in my apprenticeship I was helping a blacksmith to make a hammer, and as we were proceeding he was giving me instructions while I was blowing the



Piece of 1½ inch square steel 4 inches long, with eye punched to make a 2 lb. forging hammer.



Illustrating how fullering is done after eye is punched.



Showing side view of hammer completed with eye spread at c, (which is done with a fuller while the eye pin is in the eye of the hammer) and fullered in at e, with a larger fuller at the finish.

Fig. 13. Indicating how hammer is forged.

bellows, he said: "Never heat a piece of steel hot enough to raise a scale," (and of course at that time I thought the advice was good), however, we worked away, getting the eye punched, which was quite a hard job at that low heat, considering we had a 2 inch square piece of steel, but while we were making the hammer we had other jobs to do as is generally the case in a general blacksmith shop, and so occasionally the steel was left soaking in the fire for half an hour at a time (letting the steel lay in the fire is a bad practice among blacksmiths and is very injurious to the steel after being hot enough to work). Well, we got it forged to a very good shape, but I was not there when he hardened and tempered it (as I had given up my job). However, I called in some time after and noticed that the hammer was broken off at the corners, and also being hollow in the face.

Another blacksmith who had forged a well shaped hammer and after hardening and tempering it in his own way, found it to be as soft as lead. This hammer, I think, was hardened and tempered three or four times without success, consequently he threw it in the scrap pile, saying the steel was no good, while he "himself" was to blame as he had a very poor knowledge pertaining to the working of steel.

Now I would like to impress deeply on the reader's mind, if every mechanic could be an expert by doing his work in a rough and tumble way, the world would be full of expert mechanics, and if every blacksmith or toolsmith could make tools to give unlimited satisfaction, there would be no use in writing this book. But as this is impossible, it is necessary to have a thorough knowledge of working steel when forging hammers, and moderation in heating is the stepping stone to success.

For instance, if a square piece of steel is heated very hot and fast the corners will become overheated and if struck a blow with the hammer on the corners the steel would fly to pieces, while the steel has lost its good qualities and is spoiled in the beginning. The other extreme is trying to forge steel at a low heat, sometimes not above a blood red, while every blow that is struck on the steel is putting strains in it. What I mean by ''strains'' is the steel must be hot enough so that it will be worked clear through, and if this is not done the steel is liable to crack in the hardening. I have known hammers to crack clear through the center of the face, then all the labor is lost.

But to get the best results, forge the hammer in the beginning by having the steel at an even yellow heat, but lower the heat as the hammer is finished (all tools should be finished at a low heat, for example, a dark dull red, in order to get the best results). If much filing is to be done after the hammer is forged it should be annealed. When dressing the face end of the hammer make the corners a little rounding, but otherwise have the face perfectly flat and level, and the hammer is ready for the final blow, ''the hardening.''

Hardening and Tempering a Hammer.

After hardening there are different ways of tempering a hammer according to the shape. But for illustration, I will harden and temper a hammer as in Figure 13, but before commencing it must be understood that the face end of the hammer, at **b**, is the principal end. After getting the fire in good shape, the coal well charred and free from all sulphur and thick smoke, place the face end of the hammer in the fire from an upright position; now heat slowly and evenly, making sure that the corners do not get overheated; should the corners get hot enough to harden before the center, stop blowing the fire until the center has come up to a cherry red, or hot enough to harden even with the corners; then plunge the whole hammer in the hardening bath and hold there until stone cold. Now polish the face end (that was hardened) bright, then place the round or pene end of the hammer in the fire in an upright position and heat very slowly, as while heating to harden the round end the temper will draw to a blue in the face end if properly timed or regulated, so that one end may be hardened and the opposite end tempered in one operation, but be careful to watch both ends of the hammer at the same time. If the round end gets hot enough to harden before the temper appears on the other end stop blowing the fire until the temper begins to show up. It will not matter about the round end, after hardening, whether any temper be drawn or not, as there are no sharp corners to break off, but the temper may be drawn by holding over the fire and keep turning the hammer around, or may be done by placing a heated heavy iron band over the end.

Bear in mind that when heating the ends of the hammer to harden do not heat to a hardening heat more than ¾ of an inch back from the end, and at all times never harden the eye. A hammer that is made, hardened and tempered after these instructions will not get hollow in the center or break off at the corners or the eye. This is the author's favorite way of hardening and tempering a forging hammer and will be found very simple by the average blacksmith when once tried. Although there is another good way which is very convenient for hammers that have two face ends, such as a horseshoer's turning sledge or a boilermaker's hammer. For example, after the ends are hardened the temper can be drawn by placing a heated heavy iron band over the end of the hammer (as already mentioned). This method will draw the corners to any temper (say a pale blue), while the center will remain hard. This way will give good satisfaction as the center of a hammer cannot be too hard unless overheated, but the corners must be drawn to a very low temper. These instructions will apply to all ordinary hammers and sledges.

The old-fashioned way of tempering a hammer is by heating one end with the corners hot enough to harden, while the center is barely red, it is then cooled off by dipping an inch into the hardening bath, then allowing the temper to run down to the desired color. Consequently the hammer becomes hollow faced, could not be otherwise, as it did not harden in the center of the face at all, because it was not hot enough, and when the temper came down it made it still softer. For example, supposing a hammer face (unless it be a very small hammer) is heated very evenly, then hardened by being dipped an inch into the water, it is still bound to be soft as the temper is sure to run out at the center first.

Successful Points to Be Remembered in Making and Tempering a Hammer.

Have the eye straight through the hammer and a little smaller in the center, which will keep the handle in the hammer much better after being well fitted and then wedged. Always have the center of the hammer face as hard as the corners, but the corners must not exceed a light blue temper, unless the hammer is forged from a very soft cast steel, harden the hammer at as low heat as it will be sure to harden at. Have a good straight handle, a little spring to it is a good fault. Another good point to remember when making hammers is, do not punch the eye the full size at the beginning, but have it a little smaller, as the eye will get larger as the hammer is forged.

Punching Holes in Steel.

Punching holes in steel is considered by the average blacksmiths to be a difficult job, the trouble being they try to punch the steel at too low a heat or else they have not proper tools to do it with. Some blacksmiths use too long and straight an eye punch, consequently when the punch enters the steel a short distance the end becomes hot and upsets, causing it to stick in the steel, while the blacksmith experiences a difficulty to get the punch out of the steel. Then the punch is straightened again and the blacksmith works away until he gets the hole through. I have known blacksmiths to have a punch stick in the steel three or four times while punching one hole through a piece of 1½ inch square steel.

Coal dust is very good when put in the hole to keep the punch from sticking, but the main points to be considered is the heat in the steel when punching and proper shaped tools, especially when making hammers. And so make an eye punch and eye pin, as Figures 14 and 15. The eye punch is made from 1½ inch square steel. After the eye is punched the punch part of the tool should be forged down to an oval shape diagonally across the steel (which will bring the handle at a right angle when the punch is in use and also keep the hand away from the hot steel), and be very short and have plenty of taper, while the corners of the extreme point

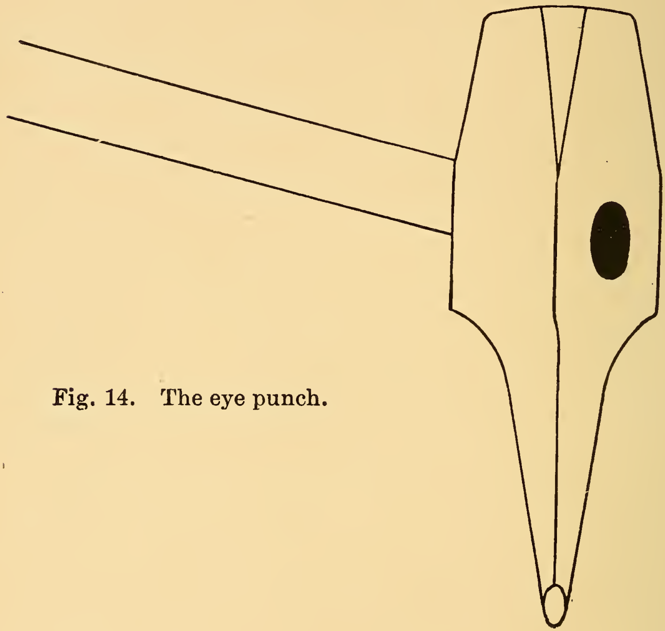


Fig. 14. The eye punch.

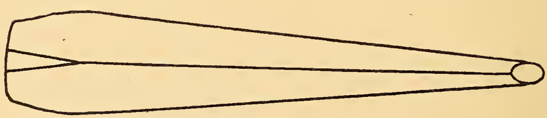


Fig. 15. The eye pin.

should be perfectly square, an eye punch of this description will not stick in the hole and will not bend.

When punching have the steel a high yellow heat, then the punch will penetrate it with more ease than if heated to barely a cherry red, and cool off the punch occasionally. An eye pin should be made from 7/8 square steel, by forging it tapering to a small square point, then to make oval, hammer down two opposite corners of the square a little rounding, which will give the shape required. The eye pin should also be short and have plenty of taper, this will make the eye a little smaller in the center when driven in from opposite sides, which will keep a handle in much better if well fitted in then wedged.

CHAPTER III.

The cold chisel—The hardy—Drills and drilling.

The Cold Chisel.

A cold chisel is a tool used by every mechanical trade and business where iron or steel is used, or wherever machinery is repaired or manufactured, and in the proper forging, hardening and tempering of a cold chisel lies the foundation and successful stepping stone in making all edged tools with a flat surface, as a cold chisel hold a good cutting edge and neither bend or break.

But the shape of the chisel is another point that must be well understood, as a fine chipping chisel which is made very thin for use on solid and soft material would not do for a boilermaker who is working on sheet steel which vibrates at every blow from the hammer. Thus, the vibration of the steel would be very trying on a thin chisel, and would consequently cause it to break, and so a heavier and thicker chisel must be made and put into use, as shown in 1, 2, 3, 4, Figure 16.

A cold chisel can be made to chip almost any kind of material, as the author has made chisels to chip from the softest known material up to chilled metal, which will seem like a fable to a great many simply because they never saw it accomplished. I have known machinists who wore out a number of new files performing some work on chilled metal, because they could not get a cold chisel properly made to chip it.

Now I would like to impress on the reader's mind that I have made chisels to chip metal that a file would not bite, but these chisels were not tempered to a blue (as a great many mechanics think a cold chisel must always be tempered to a blue), neither were they made from any old scrap piece of steel that might be handy. As I have known blacksmiths to take an old file or rasp, forge it to a round or square, and then attempt to make

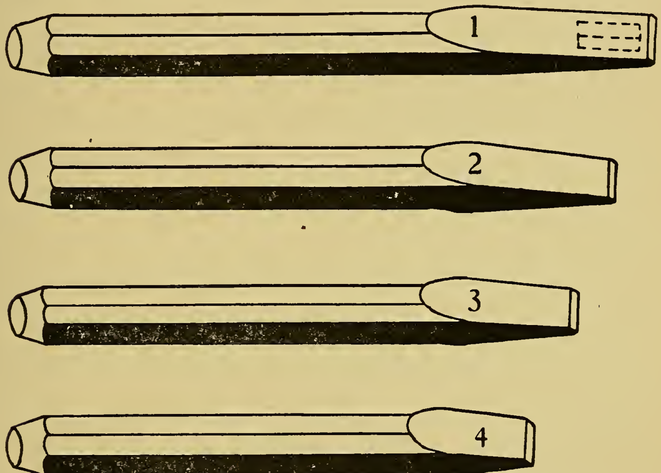


Fig. 16. Illustrating shapes of cold chisels according to use. 1. Machinist's chipping chisel. 2. Ordinary or farmer's chisel. 3. Boilermaker's chisel. 4. Chisel for chipping hard metal.

a cold chisel out of it, what nonsense. File steel as a rule is too high in carbon, being 1 per cent and over, while 75 point carbon is plenty high enough for cold chisels. Again, files in a great many cases are manufactured from a poor grade of steel; not only that, but the cuts or teeth of the file will be put deeper in the steel the more it is forged, consequently as the tool is finished the teeth of the file will be in the cutting edge of the tool (which is to be used as a cold chisel), which will break out or upset when put in use.

I will explain how the majority of blacksmith's harden and temper a cold chisel. After they have it forged to the shape, finishing sometimes with a low black heat, other times at a high yellow heat, no matter whether the last blows fall on the edge or the flat side, whichever is most convenient to bring the chisel into the desired shape, then file on the cutting edge, now for the hardening and tempering. They get the chisel hot anywhere from ¼ of an inch to 2 inches back from the cutting edge, dip into the water ¾ of an inch, holding it there for a minute or so, brighten it up a little, then allowing the temper to run down, no matter how fast, until a blue temper reaches the cutting edge, then it is cooled off and is ready for trial. Now I will point out the dangerous practices that the chisel has come through, when being hardened. The chisel was lowered into the water about ¾ of an inch and held perfectly still for a short while, now right there between the hardened and the unhardened (if the chisel was heated enough to harden far enough back) is a dividing line and a strain, and a great many chisels are broken off there from the cause of this strain. Again, if there was plenty of heat left in the steel above the hardened part, especially if hardened barely 1 inch back from the edge, the temper will run down very quickly, so that when it reaches the cutting edge, there is only ¼ of an inch that shows any temper which will be a blue, the other colors have hardly been noticed on account of the temper running down so rapidly. Thus there is only ¼ of an inch back from the cutting edge of the chisel that is tempered, while back of the tempered part the steel will be extremely soft, which is apt to cause the cutting edge to bend or break off and should the chisel be thin the tendency to break or bend will be increased.

But let us make a chisel, as No. 1, Figure 16, that will when finished cut the bar it is made from and not bend or break if used any way like a chisel should be used. Take a bar of ⅞ inch octagon good steel about 75 point carbon, cut off 6 inches, which will make a chisel about the right length. The end that the hammer is to strike upon should be drawn down a little and left square or flat on the end, then the blow will fall directly on the center of the body of the chisel and be less liable to break it. Heat the steel for the chisel end to a good yellow forging heat, draw it down near to the required shape, making it a point to have it a little narrower than just what is wanted when finished, and we will finish the chisel in a way not known to the ordinary blacksmith. Now have the chisel a low red heat so that it may be noticed to be red when placed in a dark place. Then strike the chisel five or six good hard blows on the flat side (holding the chisel very firm and level on the anvil), commencing about 2 inches back from the cutting edge, then coming gradually towards the cutting edge with every blow, when the last blow has fallen directly on the cutting edge turn the chisel over and hammer this side the same way, but be careful and do not hammer the steel too cold, but instead heat again and hammer both sides evenly as before. Then it is finished and ready for the hardening.

The hammering of the chisel on the flat sides when at a low heat refines and packs the steel, leaving it dense and much stronger than steel in its natural state, but remember this, not one blow is to be struck on the edge of the chisel, as it would knock out all the tenacity and toughness put in by the blows on the flat side, if the edges spread out a little uneven during the hammering grind or file to the right shape. Hammering steel after it gets cold or below a certain heat is injurious and makes the steel brittle and flaky as pie crust, and will never hold a good cutting edge until cut off. When hammering wide chisels, hammer in the form of dotted lines in chisel No. 1, commencing as indicated, and on both sides equally. Now we will harden and temper the chisel, after being forged as already explained, heat the chisel to an even cherry red heat 1¼ inches back from the cutting edge, then dip deep in the hardening bath at least 1½ inches, at the same time raising and lowering so as to form no dividing line of strain (and thus the hardened part will soften away gradually into the unhardened part). Polish up bright with some sand paper, emery cloth or polishing stick, as mentioned in the following pages, but after polishing there may not be enough heat left in the chisel to drive the temper down to the cutting edge, and so draw the temper by holding the chisel over the fire, heating very slowly and moving back and forward so as to get an even light blue temper all over the hardened part, then cool off. A chisel that is forged, hammered, hardened and tempered after these instructions will give the best of satisfaction, and can be placed over the horn of the anvil and struck quite a hard blow with a hammer, flatways on the chisel, without danger of it breaking or bending. The reason the chisel stands this abuse is due to the heavy hammering that was done on the flat side at a low heat, and also by being properly hardened and tempered so far back acts as a foundation back from the cutting edge.

The chisel, No. 1, Figure 16, is very thin being 1-16 thick at the cutting edge and tapering back 2½ inches to ½ inch in thickness (when made from ⅞ steel), and is classed as a machinist's chipping chisel. It will do for almost any machinist's ordinary work, but is too soft to cut anything harder than cast steel. A chisel to chip hard chilled metal, especially if struck with a heavy hammer, must be made with a short taper to form the cutting edge, as No. 4, Figure 16, and is tempered to a purple. If this is found to be too soft use a harder temper, say, a copper or dark straw. But if the metal is excessively hard, harden and draw no temper. Chisels that are made thick, are not required to be hardened and tempered so far back as thin chisels. This information applies to all kinds of chisels and similar tools. Nos. 1 and 2, Figure 17, illustrates the cape and round nose chisels. When making these chisels they should have a clearance by making the cutting edge, as A, No. 1, wider than at b, the round nose is forged round on the under side as c, by being placed in a bottom swage.

The Hardy.

The hardy is a tool used by almost every blacksmith, but more especially by general blacksmiths. It is used for numerous purposes, but its main use is, as a chisel. The cutting edge should be made thin, as the hardy is chiefly used for cutting hot iron or steel, and again if made thin it will not require so many blows from the hammer to do the work. The forging, hardening and tempering are the same as mentioned in making a cold chisel. But the points to be considered when making one is, have the shank that fits into the square hole of the anvil, fit snug so that it will not twist round, while the upper part should extend well over the sides and should be level, so as to sit on the anvil solid.

Sometimes it is necessary to make a hardy to go in the round hole of the anvil. A hardy of this kind, is made by splitting the steel, so that one part will extend over the side of the anvil which will keep it in place, as shown in Figure 19 at a. Hardies of this

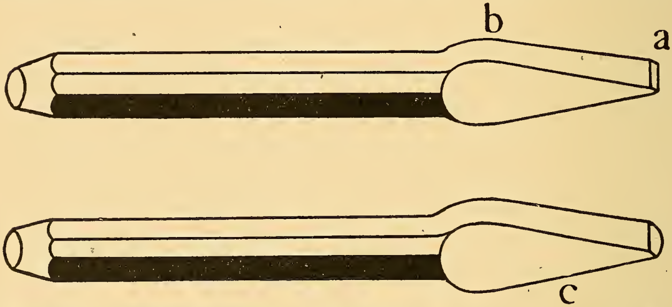


Fig. 17. Ordinary shapes of cape and round nose chisels. 1. The cape chisel. 2. The round nose chisel.

shape are used chiefly by toolsmiths when sharpening stone cutters' tools, as the square hole is occupied by holding other tools such as a stake which remains stationary. And as a hardy is also very needful, it must be made to sit in the round hole, which is the only remedy.

Heavy, Hot, Cold, and Railroad Chisels.

I have known a great many blacksmiths to try and do all their work with one chisel. Now any reasonable thinking mechanic will know that a cold chisel will

Fig. 18. Correct shape of hardy.

Fig. 19. Hardy made to sit in round hole of anvil.

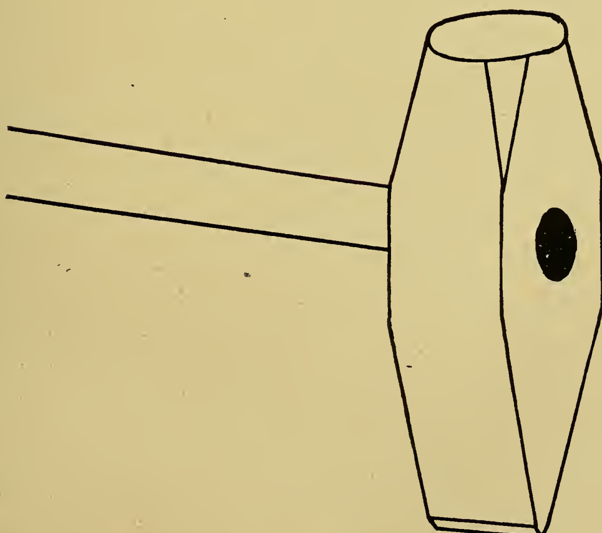


Fig. 20. The blacksmith's cold chisel.

lose its temper when coming in contact with red hot iron or steel, and that a properly made hot or splitting chisel is too thin to cut cold steel and stand the sudden shock by a blow from a heavy sledge. Yet a great many will work away trying to cut a piece of cold steel, while the chisel will barely mark it, but instead the chisel bruises up, because it has been used on hot material and has lost its temper. But the blacksmith does not think of this, consequently he puts the blame on the steel which the chisel is made from and then decides to heat the piece (he is going to cut), so that he may cut it easier. But it is a poor theory as with a good heavy cold chisel he could cut off cold, three pieces (up to a certain size), while he is heating one piece. But a great many blacksmiths think it is not possible to cut off tool steel without heating it.

But to impress on the reader's mind the necessary use of good chisels, we will take a railroad chisel, if it is well made and from good steel, it will cut at least 15 rails, while I have known some to cut 60 rails without redressing, but they did not come in contact with hot material. Although there are today a great many blacksmiths and tooldressers who cannot make a chisel cut two rails, which applies also to the blacksmiths' hot and cold chisels, a good blacksmith's heavy cold chisel should cut off at least 120 pieces of ⅞-inch octagon steel of 75 point carbon without grinding.

When making a blacksmith's hot or cold chisel, use 1½ inch square steel which will be heavy enough for all ordinary work. A hot chisel should be made very thin so as to penetrate the hot metal with ease, but a cold chisel must be left much thicker. A hot chisel, when doing a great amount of cutting at once, should be cooled off occasionally to avoid drawing the temper as little as possible. These chisels are forged, hardened and tempered as explained in making an ordinary small cold chisel, but heavy chisels, such as railroad chisels, instead of hammering with a hand hammer at the finish when forging, place a heavy flatter on the flat side of the chisel and let the helper strike it a few good heavy

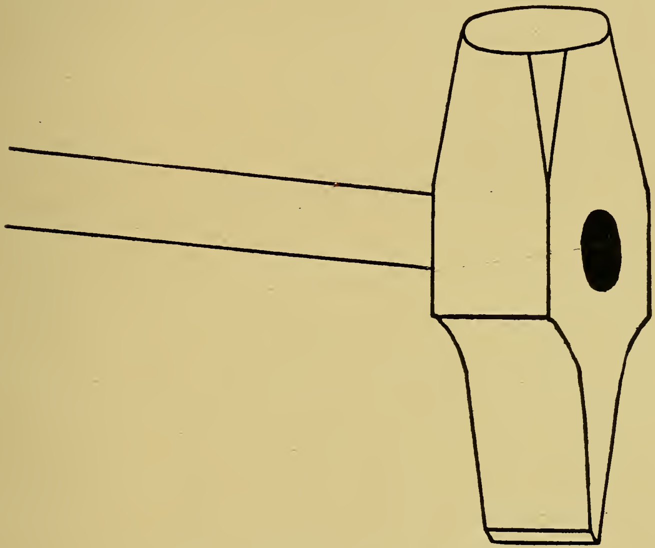


Fig. 21. The hot or splitting chisel.

blows with a sledge, then turn over the chisel and go over this side the same way, which will have the same effect on the steel as hammering with a hand hammer, and be better, as the blows will be much heavier, but be sure that the flatter comes in contact with the extreme cutting edge.

A railroad chisel is made from 1¾-inch square steel. It should not be made entirely square across the cutting edge as an ordinary chisel, but should be ground or filed rounding at the corners, as in Figure 22, which will make them more difficult to break and also give better satisfaction. If the cutting edge is tapered in from the sides to 1⅛ inches across the cutting edge, it will cut deeper when struck with a sledge or hammer and will be more convenient to get in the corners of

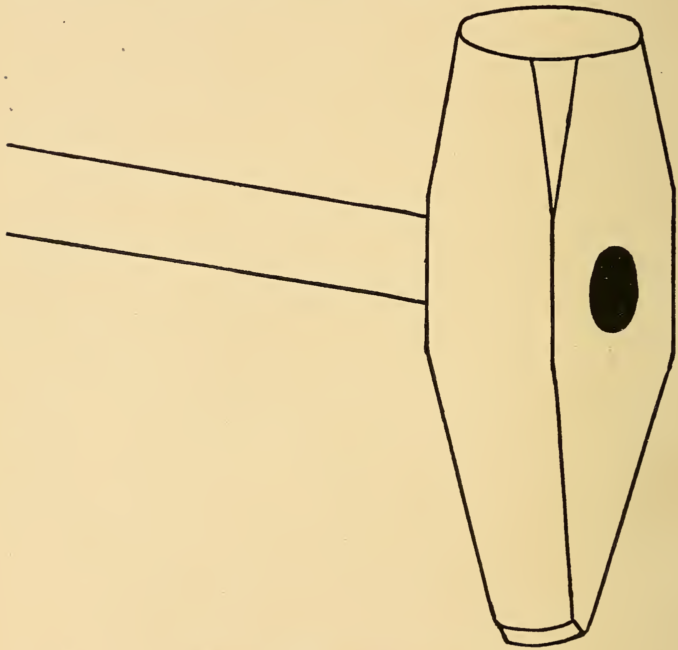


Fig. 22. The railroad chisel.

the rail than if the cutting edge was the full width of the body of the chisel.

Drills and Drilling.

Drills are in great demand, both in the machine and blacksmith shops, but where drilling by hand power is performed, is where good, fast and easy cutting drills are especially necessary. As in my first years at the trade, I had a great deal of practice drilling by hand, and with drills that were always breaking or being too soft, consequently putting the hole through often by main strength and energy, and other times with the drill squeaking by losing its cutting edge on the corners of the bit after drilling a few holes.

A great many blacksmiths prefer using machine-made drills rather than make a flat drill, because they say a flat drill will not do the work of a machine drill, and if they are asked the reason why they will say that the ones they buy in a hardware store are secret tempered or give some other reason, and often they will reply: "I don't know why." Now I wish to say to the reader that the author once made a flat drill that drilled 200 holes through a plate of hard metal ½ inch thick, and 40 holes through a plate of steel, at two grindings, without redressing. Will any machine-made drill do better? I will explain, although I mention one drill that did this amount of work. It was not tempered through guess work, neither did I strike the right temper by accident as some readers may think, as I will make any flat drill do the work of a machine-made drill, and I will go one better, as I will make a flat drill go through hard material which a machine-made drill will not penetrate. Reader, if you are an ordinary mechanic you can make a flat drill to do as well, if you will follow the instructions given in this chapter.

Making a Flat Drill.

Good tool steel of 75 points carbon will do for all ordinary drills, but for extremely hard drilling, steel of a higher carbon, say 90 points or 1 per cent, will be best. When making a flat drill, for example ½ inch in diameter, naturally the bit of the drill will be forged by making flat the end of a round piece of steel, but in forging the bit, do so if possible, by striking the bit edgewise as little as possible, and never try to forge the cutting edge of the bit, but cut off at right angles with a thin hot or splitting chisel on a piece of flat iron or copper. (This will keep the chisel from coming in contact with the hard face of the anvil, which would readily dull the cutting edge of the chisel.) Now strike the flat surface of the bit a couple of hard blows on each side while still at a low heat.

To have a fast cutting drill, the bit should be bent a little at right angles to form what is known as a lip, as in Figure 23, No. 1. Do this at a low heat (not

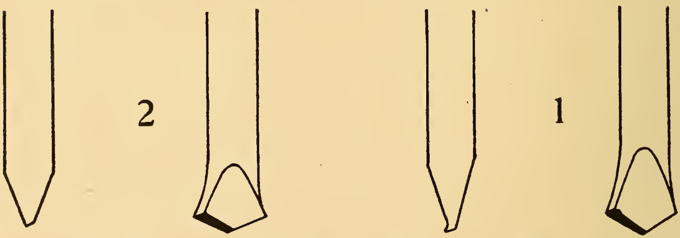


Fig. 23. Illustrating front and side views of flat drills, for hard and soft material.

exceeding a low cherry red), after the hammering has been done on the flat surface, by placing it a little over the edge of the anvil and then striking it with the hammer. This shape of a bit will cut soft metal much quicker and with greater ease than if left perfectly flat, and will equal any twist drill for fast cutting. Should the bit be a little too wide for the right size of the drill or the edges a little uneven, after being hammered and the lip formed, take it to the vise and file (or grind) on the cutting edge, but be careful to have both sides of the extreme point of the bit at the same angle, or the drill will not cut even and also cause all the strain to be placed on one cutting edge, which will have a tendency to break the drill if under heavy pressure.

Harden at a low even heat by dipping deep in the hardening bath, now polish, and draw the temper over the fire to a purple, making sure that the corners of the bit are the same temper as the point (as some blacksmiths allow the temper to run down, after not dipping deep enough in the bath to harden, and so the point of the drill is tempered while the corners are soft on account of the temper running down so rapidly). A drill that is made after these directions will do a great amount of work without regrinding if plenty of oil is kept on the cutting edge when drilling wrought iron or steel, cast iron requires no oil.

When drilling excessively hard material, such as tempered saw plate, chilled metal, etc., a perfectly flat iron drill, as No. 2, Figure 23, will be best, but it must not be drawn out so thin as a drill which is to drill soft material, and the cutting edge should not have so much bevel, draw the temper to a light straw. If this is found to be too soft, harden and draw no temper. Should this fail, heat the metal and lay a piece of brimstone on the exact spot which is to be drilled. But in heating tempered saw plate, casehardened plow mouldboards, etc., use as small a fire as possible so as not to draw the temper or hardness over more surface than just what is needed to drill the hole.

Thick bars of slate are very difficult to drill, especially when drilling such small holes as ¼ inch diameter. When drilling small holes in slate, make a drill somewhat after the same way as for drilling hard metal but temper to a dark blue, having very little clearance, and when drilling, clean the dust out of the hole often, and occasionally dipping the drill in water to keep it from becoming hot and drawing the temper.

Hand-Made Twist Drills.

It is possible to make twist drills by being forged by hand, but requires a little skill. But by following these instructions there will be no difficulty after making the first one, and drills made after the following method will be superior and outwear any twist drill that can be purchased in a hardware store.

To make a ½-inch twist drill, take a piece of ¼-inch round steel, heat and flatten out to ¼-inch thickness and allowing it to widen out 3-16 wider than the steel, and the same length as the drill is to be. The twist is then put in by holding it at a bevel on the anvil while at a deep yellow heat, but be careful not to put in too short a twist; better put in a long twist, as it will get shorter as the drill is finished. Now take a low red heat the entire length of the twist, then with a very light hammer forge the twisted flutes edgeways, beginning at the back and following gradually towards the point. By this operation the flutes will widen on the outside while the centre will remain thin. By hammering lightly at a low heat the drill will come to the required shape and be perfectly round. If the hollow grooves are more or less uneven, file them out with a small round file, but be sure that the corners of the bit will cut the full size of the drill when ground.

Harden the full length of the twist, polish bright, and draw the temper to a purple by drawing back and forth over the fire.

Making a Twist Reamer.

Of all the different kinds and shapes of reamers, a twist reamer properly made, takes the lead for fast and easy cutting. But like a hand-made twist drill requires a little skill. To make one (for example ½ inch in diameter), take a piece of ½ inch round steel. First forge the shank to go into the brace, then draw down round and tapered to about 3 inches in length, having it ½ inch in diameter at the large end and 5-16 inch at the small end. Then flatten out to ¼ inch thickness at the large end and ⅛ inch at the small end. To put in the twist commence at the large end which will be best

Fig. 24. Illustrating how reamer is forged, before being twisted.

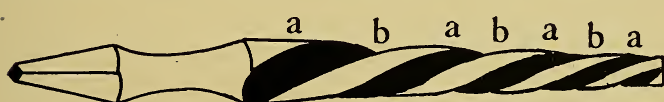


Fig. 25. The twisted reamer completed

done in a vise by the use of a wrench, but the twist in the small end can be done with the hammer by holding at a bevel on the anvil, then hammer as mentioned in making a twist drill until the reamer comes to the shape required. But bear in mind the twist is put in to the left, while to cut the reamer is turned to the right.

The cutting edge of the reamer is illustrated by "a, a, a, a," Figure 25. But back from the cutting edge to the groove shown at "b, b, b," when filing should be left a little smaller which will act as clearance thus allowing the extreme cutting edge to come in contact more readily with the work.

Harden as a twist drill and temper to a purple. Should the twist be put in a reamer as in a twist drill (which is put in to the right), the reamer will draw into the material too fast, and be liable to break it. Also bear in mind not to give too much clearance or the cutting edge will take hold of the material too readily and stick, for a ½-inch reamer 1-32 clearance will be plenty and for smaller sizes less will do. When filing on the cutting edge have a thin flat iron plate with different size of holes in it to form a gauge and so regulate the clearance. File out the hollow grooves very smoothly and evenly so as not to leave any thick spots in the cutting edge.

The Polishing Stick.

A polishing stick is made by taking a piece of pine or other soft wood, which should be round, about 1½ inches in diameter and 15 inches long. Wrap a coarse sheet of emery cloth or sandpaper around it, then drive in two or three carpet tacks to hold it in place. This will be much handier than a piece of loose sandpaper. Do not use sandpaper after it becomes worn smooth, as it will not brighten the steel satisfactory in order to see the correct temper.

CHAPTER IV.

How to draw out an axe—Mill picks—Butcher knives—Fine springs—Dirt picks.

How to Draw Out, Harden and Temper an Axe That Will Cleave a Hemlock Knot.

Almost every country blacksmith has had more or less axes to draw out (as the saying is), but there are very few who have a reputation of being able to dress an axe so that it will cleave a hemlock knot, without breaking or otherwise having the cutting edge bent over. And yet how many axes have been thrown into the scrap pile, after coming through the process the blacksmith gave it, by being cracked sometimes half way across the bit and occasionally a piece dropping right out, and every blacksmith who has had any experience repairing axes will know this statement to be true. I have known farmers and lumbermen who owned axes which were known to cleave a hemlock knot and still hold a good cutting edge, refuse to part with them when offered three times the amount that would purchase a new axe. I have had farmers offer me a dollar to dress one axe, while they could go to a hardware store and buy a new one for the same amount. "Why?" Because it would hold a keen edge and they could rely on it, and they were not afraid of breaking a piece out of the bit when chopping hard or frozen timber.

I remember drawing out an axe for a farmer, and after grinding it I told him to try it on all the hemlock knots he could find. But being a little suspicious he asked me if I would go to the woods with him, which was but a short distance from the shop, and I consented to go. After reaching the woods I found some large knots and told him to go ahead and try his axe, but he hesitated and made no offer to do so, so I took the axe from him and chopped into a knot, and after striking a few good blows I handed him back the axe. The first thing he did was to examine the cutting edge as he was expecting to see a piece missing from it, but it was all there the same as it left the grindstone. Imagine his surprise. I saw him a few days after and the first thing he said was: "I have been using the axe ever since and cutting every hemlock knot I could find and the axe is as good as ever." Reader, I am not relating this experience to fill up an extra page in this book, but to impress on your mind the benefit of making good tools, and in this case especially an axe.

I will explain the way the ordinary blacksmith goes about to draw out an axe. He gets a low heat on the bit and commences to hammer it and entirely on the cutting edge. If the axe gets too wide he turns it up edgewise and drives it back straight again, sometimes loosening the steel, but works away until the axe is forged into a shape to suit him. Now he hardens and tempers it after this fashion, he places it in the fire, gets one corner at a white heat while the other is barely red, dips it in a tub of dirty water about an inch deep (but if it does not crack in the water it will shortly after). Then the temper runs down sometimes one color, other times another, while on the other hand the temper runs down so rapidly that the corners become soft and only the centre of the bit is tempered, The causes for the axe cracking are—by uneven and overheating which is the main cause, while another cause will result from improper forging or hammering the steel unevenly when at a low heat, and so drawing or working the steel on the outside while the inside has not moved, and between the two there is a sort of tearing operation going on which will increase the tendency to crack when hardening.

Now let us dress an axe properly as it should be done. An axe that is rather thick is best for the process, as it gives us stock to work on. After preparing the fire, having the coal well charred and large enough to heat

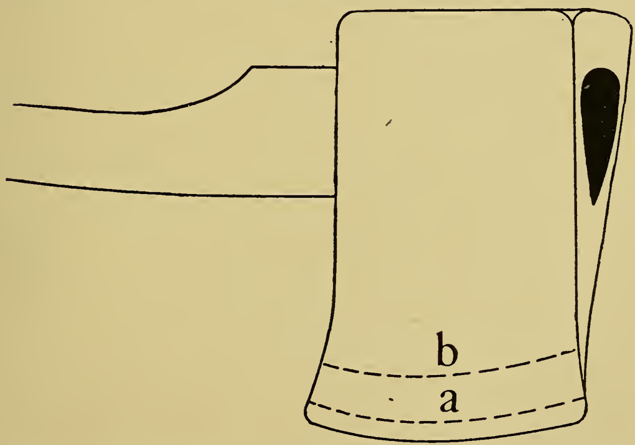


Fig. 26. Lumberman's chopping axe, dotted lines, a and b, indicate how to avoid strains in the steel when dressing.

the axe evenly the full width of the bit or cutting edge, heat evenly to a deep yellow; now commence to draw out by hammering, beginning at the cutting edge, going all the way across the bit, as indicated by dotted lines **a**, Figure 26, then turn over, going over this side the same way until the heat begins to get low and the edge is drawn as thin as is necessary for an ordinary chopping axe. Now we will take another heat, this time 1½ inches back and to a good yellow heat, but instead of going over the edge as before, go back 1¼ inches from the cutting edge, as indicated at **b**, Figure 26, and hammer both sides the same. Now the axe has widened out, but instead of turning it up edgewise and striking it with the hammer, cut it off with a chisel to the proper width. (A little narrower will be best as the axe is not finished yet, and the steel will come as wide as is necessary in the finishing stage and will also save filing.) Now heat the axe again, this time to a very low heat, just hot enough so that it will be plainly seen to be red when put in a dark place, and hammer entirely and evenly all over the flat surface and both sides the same for 1½ inches back after the same fashion as the first time, but this time hold the axe solid and level on the anvil and do not hammer the steel after it gets too cold, otherwise the tenacity that is being put in the steel with the hammer will be destroyed. The axe is now drawn out and after cooling off and filing the edges smooth, it is ready for the hardening and tempering. When hammering the axe in the finishing stage, about 15 good blows on each side will be enough. If the hammering is properly done at the right heat the steel will show a bright black gloss.

To harden the axe, heat the bit slowly and very evenly not less than 1¼ inches back, to a cherry red or just enough to harden, dip deep into the hardening bath not less than 1½ inches, raising and lowering so as to soften gradually, thus causing no strain in the steel. Polish the hardened part bright, but as there is not enough heat left in the axe to force the temper to run down, draw it by holding well over the fire, heating very slowly and moving back and forth so as to insure an even temper (but be careful and do not let the extreme thin cutting edge draw the temper first), until the whole bit of the axe for 1¼ inches back will show a light blue, then cool off and grind.

An axe that is forged, hammered, hardened and tempered after these directions, will be free from all cracks and will hold a very keen cutting edge, and if broken in use will be done by carelessness. When dressing an axe, the shape of the bit will depend upon the user, as some want a bit very rounding, others want the bit almost square.

When dressing double bitted axes, dress both ends before undertaking to harden and temper. When hardening and tempering be careful not to draw the temper in the first end when heating to harden the last end, but place the tempered end in water occasionally. A good chopping axe should be slightly thicker in the centre of the bit than at the corners, which will burst the chips more readily.

Mill Picks.

Mill picks are something that are very little understood by the average blacksmith, and I have known millers to send them 500 miles, in order that they might get them dressed and hardened properly. And as almost every blacksmith would like to know how, I will give the process. When making mill picks use steel of medium high carbon, say 90 points, as mill picks require harder steel than ordinary tools, as they have to cut very hard material, while the blows are very light.

There are different sizes of mill picks which depend on the miller who is going to use them, ranging in weight from 2 to 4 pounds, but the medium-sized pick of about 3 pounds weight is most used. There are also different styles of mill picks, some have an eye punched in them for a handle, while others are made to fit in a socket. The main object, however, is to have a mill pick drawn out thin and hardened properly, in order to do a great amount of cutting and hold a good cutting edge, without being ground often or having the corners continually breaking off, which is dangerous to the miller's hands and eyes.

Now supposing some picks are to be dressed. The

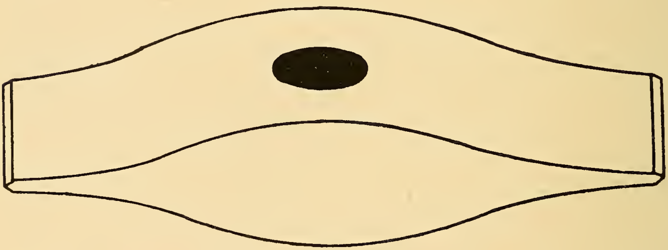


Fig. 27. Correct shape of mill pick.

first thing to do is to draw the hardness by heating one end to a low red, before dressing the other end, otherwise there will be a tendency of the end held in the tongs to break off, when dressing the opposite end, unless the picks are very thick. Heat the end to be dressed or drawn out, to a deep yellow heat (so that the steel will be worked clear through, thus leaving no strains which would afterwards cause cracks), draw it out thin to 3-16 of an inch thick on the cutting edge, tapering to ⅜ of an inch thick, 1½ inch back, at the same time having the cutting edge barely as wide as the body of the mill pick. Now heat again to a low dark red, have a hammer weighing not less than 3 pounds, hold the pick perfectly solid and flat on the anvil without raising or lowering it, and strike 5 or 6 good blows on the flat side, making sure that the hammer will fall on the extreme cutting edge, then turn over and go over that side the same way. Do not strike every blow in the same place but go over the whole flat surface of both sides evenly and do not hammer the steel after it becomes black, but heat again to a very dull red and strike 3 or 4 more blows on each side evenly, and it is done. If the edges have spread out a little wide or uneven, do not attempt to strike one blow on the edge, but if necessary to have them straight, file or grind, although it makes no difference should the cutting edge of the mill pick be a little wide, as all the miller wants is to have them cut good. Now one end is dressed, go over the other end exactly the same way (before undertaking to harden), the cutting edge is filed on the same as for an ordinary cold chisel.

To harden a mill pick, heat evenly to a low cherry red or just hot enough to harden at least 1½ inches back from the cutting edge, then plunge into the hardening bath and cool until entirely cold. Then harden the opposite end after the same method, but be careful not to draw any temper in the end already hardened, and the pick is all ready for use. Do not draw any temper on mill picks as they will not be too hard if properly hardened. When hardening mill picks, harden one end at a time and never try to harden both ends at once. The right size of steel to use when making ordinary mill picks will be 1½ inches square, but for smaller sizes 1¼ inches square will do.

Butcher Knives.

There is a saying that has been going the rounds for a long time, which is: "Always use a file to make a butcher knife," but any blacksmith who believes in this saying or theory does very little thinking for himself. I have seen dozens of butchers' knives made from files, but what were they like? They were stiff, without any spring to them, were easily broken and would not hold a good cutting edge, on account of the teeth in the file, and to have a good butcher knife it must be just the opposite—it must hold a keen edge and instead of breaking, it must be very pliable, as whalebone. Although butcher knives are made almost entirely by machinery, machine or factory-made knives will not hold the keen cutting edge that a hand-made knife will when made from good steel and properly hardened and tempered. A great many machine-made butcher knives are made from poor and cheap steel, consequently they are sold cheap.

To make a butcher knife, use steel of about 75 point carbon. The proper size of steel to use for an ordinary size butcher knife will be ¾ by ⅛ inches. After the shape of the shank has been decided on, which may be flat, as **a**, Figure 28, forged or square as in Figure 29. Now, for example, we make a knife 8 inches long in the blade. The first thing to do (after cutting off the steel the right length) will be, take a chisel and cut off at right angles, as **c** in Figure 28, to form the point. Now crook the steel edgewise in a circular shape as Figure 28, the depth of the crook being about ½ an inch, then get a deep red heat half the length of the blade and draw to a thin edge, at the same time hammering evenly from both sides of the steel, beginning at b, Figure 28, on the inside of the crook, then heat the other half, and draw the edge until the point is reached. The crook that was put in the steel edgewise

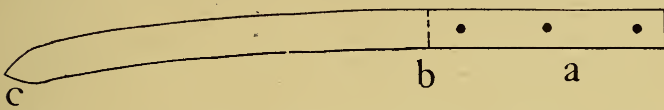


Fig. 28. Piece of steel bent, drilled and pointed to make butcher knife.

has all come out and the knife is straight. Now flatten the point, making it thin and a little wider than the body of the knife. Never try to forge the point of the knife, but cut to shape with a chisel. Now take a very low heat the length of the blade of the knife, and hammer equally on both flat sides of the cutting edge to refine and pack the steel. Now heat again to the same low heat, but instead of hammering the cutting edge

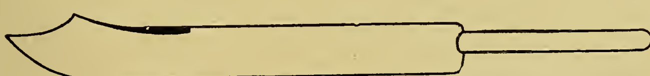


Fig. 29. Illustrating carving knife, without handle, and forged with a square shank.

hammer in the centre of the blade, both sides evenly and the full length of the blade. Cool off and after filing the edges straight it is ready for hardening.

In hardening the knife have the fire a long shape, which will heat more of the knife at once. Now put the knife in the fire with the cutting edge downward, and move the knife back and forth so as to get a very even heat the full length of the blade, just hot enough to harden. Then plunge lengthwise with the cutting edge down into the hardening bath and cool entirely. Now, if the knife has been forged and hammered evenly the whole length of the blade, it will not come out of the hardening bath perfectly straight, but there will be a crook in it. For explanation we will say there is a crook in it. Now take a polishing stick and brighten one side of the knife. To draw the temper, place flat-

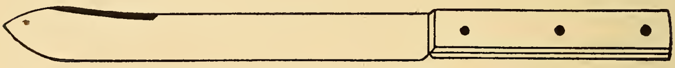


Fig. 30. Ordinary butcher's knife.

wise over the fire (do not place the knife directly on the hot coals, but instead, hold about 2 inches above), with the brightened side up. Heat very slowly, at the same time moving back and forth to insure a very even temper; draw to a pale blue, but before cooling place

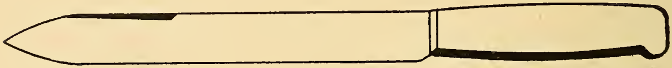


Fig. 31. Straight pointed knife.

the knife on the anvil and take the crook out by striking it with a hammer, then cool, and it is ready for the grindstone. The reason that the crook was taken out so easily is, when the knife was being heated to harden only two-thirds of the width of the blade was heated enough to harden, consequently the back of the knife remained soft. This, with what heat was in the knife after the temper was drawn, allowed the knife to bend without springing back.

To have good success when making butcher knives, bear in mind to forge and hammer evenly on both flat sides, have a yellow heat when drawing the cutting edge, and a very low heat when hammering for the last time, and never attempt to strike the knife edgewise in the last hammering. Remember that the hardening of the knife must be carefully done so as to harden the full length of the blade without leaving any unhardened spots; also, as much pains must be taken when tempering so as to have it evenly drawn and so avoid having hard or soft places.

How to Make Gun, Revolver, Traps and All Fine Springs.

Springs perform a very important part in mechanical appliances, and especially guns, revolvers, and traps of all kinds, but to make a good spring the process must be thoroughly understood. When making springs, steel of about 60 points carbon is best, and never use steel for spring making that exceeds 75 point carbon, and bear in mind when making a spring to make it as wide and as thin as possible according to the work it is to do.

When making springs, as gun springs, in the first place forge the spring perfectly straight, but leave it a little less than the right width, also leave it a little thicker than the spring is to be when finished. Now heat the whole spring from end to end to a very low heat (say a dark dull red), and hammer with heavy blows evenly on both flat sides, being careful to keep the spring very straight without hammering the spring edgewise. As the hammering of the spring on the flat sides, when at a low heat, is to refine and pack the steel which is one of the greatest secrets in successful spring making. To bend the spring, heat it to a blood red (never exceeding a low cherry red), where the bend is to be, then bend to the proper shape. If at any time it is necessary to make a spring with a crook or offset in it edgewise, the crook must be put in the steel before the last hammering is done, so that the steel may be refined and packed by the hammer, thus increasing the tenacity of the spring, but do not hammer the steel below a certain heat, as the tenacity of the steel will be ruined when hammered too cold.

There are different ways of tempering springs, but only the simple and most successful methods are given. To harden, heat the entire spring in the blaze of the

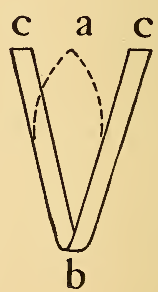


Fig. 32. Illustrating the elastic strength of a well made spring.

fire, very evenly to a cherry red or just enough to harden, then plunge into the hardening bath and cool off "dead cold." Then polish it bright. To temper, hold the spring edgewise 2 inches above the fire, and do not blow the fire, but heat very slowly, moving the spring back and forth and occasionally turning over to insure a very even temper, watching very closely until the spring has drawn to a very pale blue, almost grey. Do not cool off in water as other tools after the temper is drawn, but lay it down somewhere away from a draft of cold air allowing it to cool off slowly on its own accord. This is the author's favorite way of tempering a spring, and a spring as Figure 32, made after these directions, which for example, is 2 inches long and 1¼ inches between the ends **c c**, 1-16 thick and 5-16 wide, can be bent as indicated by dotted lines at **a**, until the ends meet, without fear of breaking or remaining bent, but instead will spring back exactly the same distance apart, as the ends were before being bent.

Still another good way of tempering a spring, after being hardened as formerly mentioned, and which will save polishing. Hold the spring over the fire, placing it in a dark place now and again, until it shows a very dark red, just visible to the eye. Then lay down and

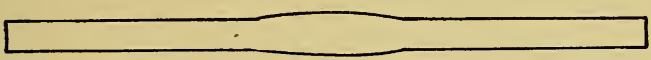


Fig. 33. Showing how trap springs are forged before being bent to shape.

allow it to cool off on its own accord, but in tempering a spring after this method have a dark place close to the fire.

When hardening or tempering a spring of any kind, hold it with the tongs at the extreme end, as the spring if held by the tongs in the centre, the place held directly between the tongs will have a great tendency to remain soft, which would spoil the spring and cause it to bend out of its proper shape when put into use. And bear in mind to harden and temper the whole spring evenly from end to end. A great many blacksmiths harden a spring in oil, but the error of this way is, the steel must be heated to a higher heat to harden in oil than water or brine, which is sure to decrease the elastic strength of the spring. In large factories where springs are made in great quantities, they are heated to harden, in hot lead or in a furnace, while the temper is drawn in boiling oil, tallow, or hot air. The degree of heat required to draw the temper is registered by a pyrometer connected with the vat or furnace, which insures a very fine and evenly tempered spring.

When making trap springs, or springs for a similar purpose after the fashion of Figure 32, have the spring at **b** a little wider than the rest of the spring and give it a short bend, which will increase the strength of the spring. Fine flat springs which have a long gradual bend when in use (especially for very light purposes), require no hardening or tempering as there will be enough spring to them, by simply hammering them equally on both sides when at a low heat.

Dirt Picks.

All tools of this description are used a great deal by railroad laborers, farmers and others, who work among gravel, hard ground, etc. Dirt picks are principally made from iron, while the ends are laid with steel which should be good ordinary tool steel of 75 points carbon. In dressing the ends, follow the instructions given in making or dressing a cold chisel, making sure to dip deep into the hardening bath, when hardening so as to give a foundation back from the cutting edge and keep the points or ends from bending and more especially if the pick is drawn out very thin, temper to a light blue.

For laying picks, I will give some instructions to insure good results and so produce a good weld. The steel for this purpose should be ¾-inch octagon or square, for ordinary picks, but if the picks are of a large size larger steel should be used. In welding of this kind always insert the steel into the iron, and don't make too long a weld, as a short one of reasonable length is best and much easier made. Always have plenty of stock when making a weld, so that the weld will need no upsetting in order to bring it to the right size.

Now draw down the end of the steel that is to be inserted in the iron in forming the weld, to a tapered or V-shape, and drawn to a thin square edge and having it at least ¼ of an inch wider than the weld is to be; cut a little piece out of the center after a V-shape and put some nicks in the beveled part of the steel with the corner of the chisel, making it very rough as No. 1, Figure 34. Cutting a piece out of the center of the

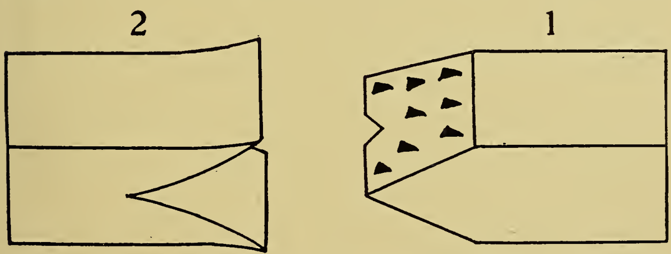


Fig. 34. Illustrating how ends are forged when laying dirt picks, in order to make a successful weld.

steel enables it to go well up into the iron. Take the iron part which is to form the weld, after heating, split it with a hot chisel as far back as required, open the ends and draw down to a thin edge as No. 2, Figure 34. Now take a good heat on the iron and insert the steel while at a low heat into the opening of the iron, driving the steel well up into the iron, then hammer the ends of the iron well down over the steel. (The nicks that were put in the steel will enable it to stay in the iron much better during the welding heat, than if left perfectly smooth.) The pick is now ready for the welding heat. Have the fire clean with plenty of well charred coal, heat the place to make the weld to a cherry red, then place plenty of fine powdered borax on it, then heat to a welding heat as high as the steel will stand, but no more. Bring from the fire and strike the end against the side of the anvil or strike the end with the hammer, driving the steel well up into the

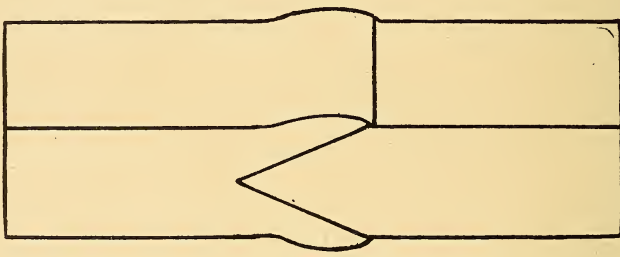


Fig. 35. How ends are placed together, showing plenty of stock to make the weld.

iron, then strike the first few blows (to make the weld) lightly and on the flat surfaces of the iron, then hammer hard and fast and from all sides alike until the weld is completed. If the weld is made after these directions, it will be perfectly smooth and solid and will show no trace or opening where the steel was inserted in the iron. The reason it will show no opening in the weld is because the steel was left wider than the iron and when being welded was driven back, filling the opening, that otherwise would have been there and so leaving the weld perfectly smooth and as solid as one piece.

Bear in mind that when making a weld after this description, have the iron well down over the steel as in Figure 35, and so leave no opening to allow dirt and other ingredients to get in when taking the welding heat, as steel will not weld successfully if any foreign matter gets in between the welding surfaces, no matter whether the weld consists of iron and steel or two pieces of steel. Also remember when taking the welding heat to keep plenty of fine powdered borax on it, so as not to allow the steel to become dry in the fire, and when making the weld strike the first three or four blows lightly, as the steel will unite more readily, than if the first few blows are struck very heavy.

When welding two pieces of steel and one piece is harder than the other, always if possible insert the hard piece into the soft piece, otherwise the steel is more apt to get overheated. And also bear in mind to take the welding heat of the harder piece, instead of the softer piece.

CHAPTER V.

Machinists' tools—The use of asbestos and clay when hardening tools—Boilermakers' tools.

Machinists' Tools.

Connected with the machinist's trade is a wide range of fine and complicated tools. Among them being lathe and planer tools, milling cutters, taps, dies, reamers, etc., and the toolsmith in a large shop who can forge, harden and temper these tools satisfactory will have a great many friends among the machinists, but should the toolsmith be otherwise, there is nothing that tries the temper and patience so much as to have a number of machinists continually around the fire and each one making a complaint that the tool would not do this, and it would not do that, etc.

When making lathe and planer tools, there is no definite rule to go by "as to the shape," with the exception of a few standard or ordinary tools, as shown in Figures 36 to 46, as the machinist has so many jobs of a different nature that he requires a tool of a special shape to suit the work, which he explains to the toolsmith or gives him a drawing of it, and sometimes a pattern of it made from wood. Steel of 1 per cent or 100 point carbon is best for making lathe and planer tools, as these tools do their work by steady pressure. But nevertheless they must be properly forged, hardened and tempered, in order to stand the great strain that is continually bearing against them, and also to hold a good cutting edge in order to save time, and do work of a very exact and skillful nature, especially in the finishing stage.

Lathe tools of a flat surface, such as bent cutting off tools and side tools, must be forged to shape and the offset put in before the last hammering is done. When making cutting off tools and other tools of a similar nature, always give plenty of clearance as illustrated in Figure 38, which shows the cutting edge **a** a little

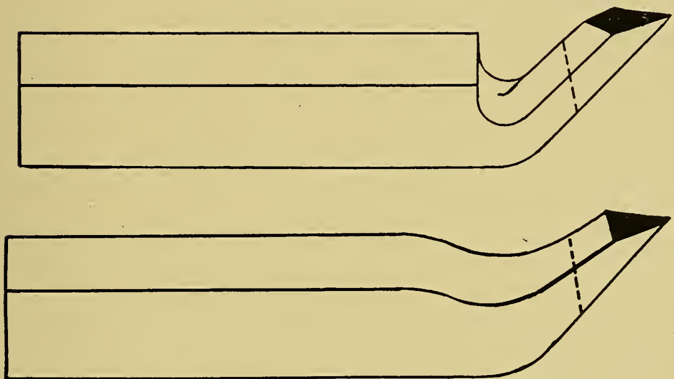


Fig. 36. Two ways of forging a diamond point lathe tool.

wider than **b**, also wider than **c**, as shown in front view of the same figure, and bear in mind when forging the tool leave it a little wider at the cutting edge than the exact width, as the hammering on the flat surface after the offset is put in, will bring the cutting edge to the right width. To more fully explain let us suppose the cutting edge of the tool is to be ¼ of an inch in width, but in order to refine and pack the steel, we will have the cutting edge 5-16 of an inch wide before undertaking to hammer on the flat surface. If the hammering does not flatten the steel to exactly the right size and so leave the cutting edge a trifle wider, so much the better, as the tool will have a little stock for grinding.

All lathe and planer tools for ordinary work should be quenched or hardened about one inch back and ac-

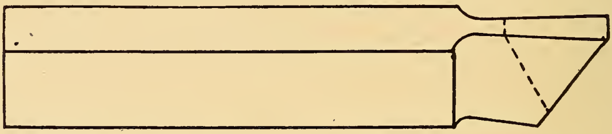


Fig. 37. The straight cutting off, or parting tool.

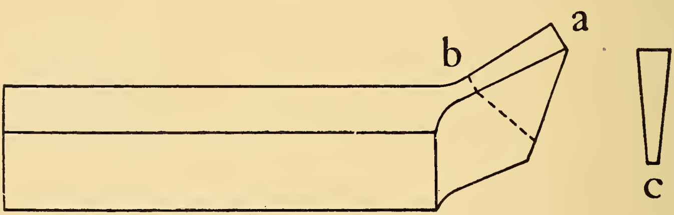


Fig. 38. The left hand bent cutting off tool.

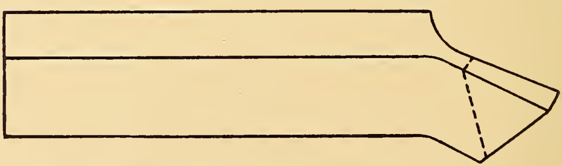


Fig. 39. The right hand bent cutting off tool.

cording to the cutting edge, as illustrated by dotted lines in Figures 36 to 45, and tempered to a dark straw or copper color. But should the tools have to cut very hard cast iron or other very hard material, harden and draw no temper. Should the tool still fail to cut the metal, use equal parts of powdered cyanide of potassium and prussiate of potash. To use this compound heat the tool as hot as if it was to be hardened, then place the heated, cutting edge of the tool into the powder, reheat again to a proper hardening heat and plunge into the hardening bath and cool off entirely.

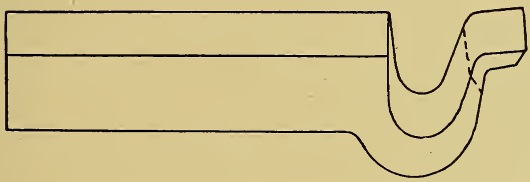


Fig. 40. The spring tool.

When hardening large tools such as square corrugating tools, and which have very fine teeth in the cutting end, as indicated in Figure 46, make sure when heating that the center of the cutting face is as hot as the outside or corners. And never heat carelessly or too fast, so that the corners will be at a white heat,

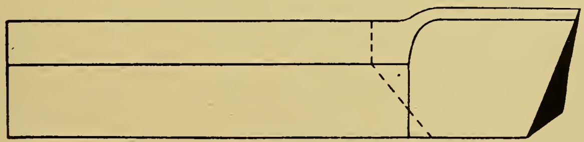


Fig. 41. The left hand side tool.

while the center is barely red. But heat slowly and very evenly, until the whole face of the cutting end is just hot enough to harden, then plunge into the hardening bath and cool off entirely. Draw no temper.

Heat slowly and evenly until the whole face of the cutting end is just hot enough to harden, then plunge in the hardening bath and cool off. Ordinary corrugating tools require no temper drawn.

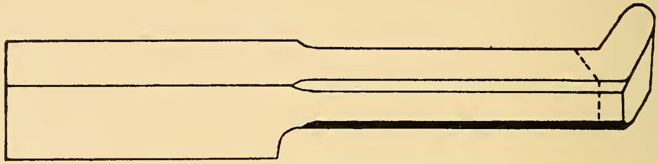


Fig. 42. The inside boring tool.

Air Hardening Steels for Lathe and Planer Tools.

Cast steel for lathe and planer tools is to a certain extent done away with in large shops by the use of air or self-hardening steels. A certain amount of this steel is manufactured in sizes so that no forging of the tool is required, and by the use of a patent toolholder (made especially for certain sizes of the steel) is su-

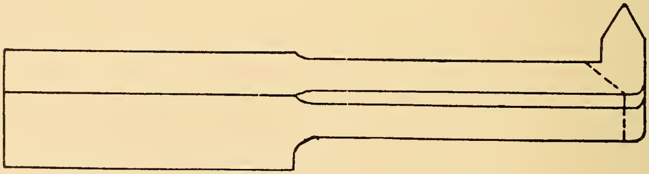


Fig. 43. The inside ordinary thread tool.

perior to a hand forged tool in some respects. But the toolsmith has an important work to do connected with air hardening steel, as he is called upon to cut it off in lengths and harden it, besides. As there is a limit to the sizes that are manufactured for immediate use the steel must be forged to the shape of the tool, while the forging and hardening of air hardening steel is somewhat of a different nature to cast tool steel. Air hardening steel is not as a rule used for anything but for roughing lathe and planer tools, it being too hard to make into any tool which is to do its work by the use

Fig. 44. The inside square thread tool.

of a hammer and also to make into any expensive tool such as milling cutters, as on account of its extreme hardness it cannot be machined or worked satisfactory. There are several makes and brands of air hardening steel, but some of the leading makes may be mentioned as, Sanderson's, Jessop's, Novo, Mushet and Blue Chip.

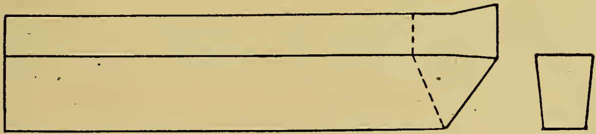


Fig. 45. The broad-nose or finishing tool.

When forging these brands into tools do not heat the steel above a bright yellow, especially Mushet or Sanderson's, but the steel must be heated evenly clear through the bar, and unless the tool is to be of a fine nature do the forging under the steam hammer, as the steel is too hard to forge with the hammer and sledge. The forging should be done as quickly as possible, while the heat is in the steel, and never attempt to bend or crook the steel when at a low heat, as it will be apt to crack or break in two, so be careful to have the steel at least at a deep red heat when it is to be bent.

When any new brand comes in the shop be careful to look at the directions on the bar, as some brands are hardened a little different from others. For example, the cutting edge of a tool made from Blue Chips is hardened by being heated to a white heat until it commences to melt, when small bubbles or blisters will

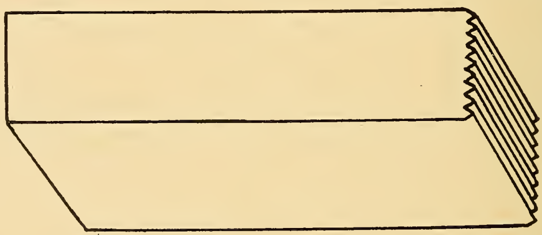


Fig. 46. The corrugating tool.

form on the steel, then it is placed in a blast of cold air. To harden Mushet steel heat to a deep yellow and cool off in a blast of cold air, Sanderson's and Jessop's after the same process. Novo steel is hardened by heating it to a white heat, then cooled off in a blast of cold air or may be quenched in oil.

When hardening steel with a blast of cold air, have the pipe or nozzle (which conveys the air) as close to the fire as possible, and when cooling off the tool, have some arrangement to hold the point or cutting edge directly in front of the blast. If this is not done the tool is apt to become turned to one side by the force of the blast. Also bear in mind if the steel is heated to a melting heat, as Blue Chip, be careful not to put the blast on too strong at first or it will blow the point off the tool. Instead put on the blast light and gradual until the steel begins to cool a little. Then turn on the blast to its full capacity and keep it on the tool until it is perfectly cold.

A great deal is to be learnt in working air hardening steel in order to get the best results. But for the beginner who has had no experience, follow up the directions given by the manufacturer. Should the directions fail to give good results do some experimenting. For illustration Novo brand of steel will give good results if heated to a white heat, then plunged into oil or boiling water, while Blue Chip will sometimes give better results if (after being heated to a melting point and cooled off in a blast of cold air) it is heated to a very low black red heat and allowed to cool of its own accord. Yet there are other brands of steel which are hardened by heating to a light yellow heat, then placed in a cool place and allowed to cool slowly of its own accord.

Never allow Mushet steel to come in contact with water or it will crack, although no visible heat can be seen in the steel. Figure 47 illustrates a heavy roughing tool, made from air hardening steel for turning locomotive tires, car axles, etc. Dotted line at a indicates how far back from the cutting edge, as b, the steel is to be heated when hardening. All roughing tools are made after the same shape. Bear in mind when forging air hardening steel, never try to forge it below a low cherry red and if at any time it is necessary to cut a bar into lengths, do not try to cut it cold, as it must be heated.

How to Anneal Air Hardening Steel.

Sometimes, although seldom the toolsmith is called upon to anneal air hardening steel, so that it may be turned or planed. This class of steel is very difficult to anneal on account of its extreme hardness. It must not be packed directly in slacked lime or ashes as cast tool steel, as it will cool off too quickly. To anneal air hardening steel, use an air tight heavy iron box, place the steel inside the box, then heat altogether to a deep red heat, then pack the box deep into slacked lime or ashes. If an iron box cannot be obtained, use a heavy iron pipe or band large enough to accommodate the

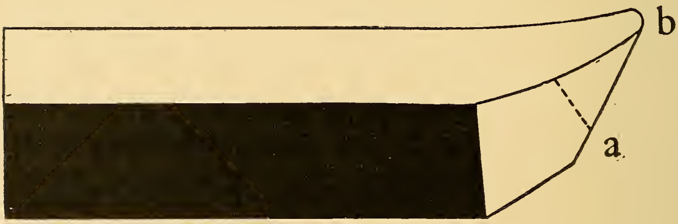


Fig. 47. Heavy roughing tool.

steel, without having the steel project out through the end. Also have two heavy flat iron plates large enough to cover the end of the pipe. Place the steel in the pipe and heat the pipe, likewise the plates, as formerly mentioned, then pack the pipe into the lime in an upright position, having one of the plates directly under the pipe, the other on top, which will keep the steel from coming in contact with the lime. By following this method the steel will keep hot a very long time, and thus give good results. To anneal a piece of 1-inch square air hardening steel will require from 12 to 15 hours' time.

Milling Cutters.

These tools are very valuable to the machinist's trade, and the making of them requires great skill, valuable time and good steel, which makes them very expensive tools. If they are not properly forged and hardened there is a great loss.

When forging a blank for a milling cutter (steel of about 90 point carbon is best) be sure and leave the blank a little larger every way than the exact size of the milling cutter when finished, as a machinist always prefers a little extra stock, which enables him to machine the tool with greater ease and less caution than if forged to the exact size of the tool. When forging a milling cutter heat the steel evenly to a good yellow, but do not heat too fast or the outside or corners will be at a white heat while the inside is barely red, and by unevenly heating will cause strains which will produce a tendency to crack when hardening the milling cutter.

If the milling cutter is large forge it to shape under the steam hammer being careful to forge it evenly from all sides alike and so work the steel clear through, but as it becomes finished reduce the heat. Tools such as milling cutters which are either round or almost of an equal size, cannot be refined, as the steel will remain at its natural state, consequently it is not desirable to finish at quite so low a heat as those of a flat surface. But if the milling cutter is very thin and flat then the steel may be refined by using a flatter on the flat surface while at a low heat.

After forging the milling cutter it must be annealed, which operation must not be neglected, as the whole blank must be heated again slow and evenly to a blood red (never exceeding a cherry red), then packed deep into slacked lime, allowing it to remain there until cold. Have the annealing box large enough so that it will contain plenty of lime to keep the heated steel away from the air. If there have been any slight strains left in the steel by forging the annealing will take them out and make the steel soft so that it can be worked with ease by the machinist.

The hardening of a milling cutter after it has been machined to shape, is the process that must not be overlooked, as in the hardening the toolsmith must either succeed or spoil the tool. The milling cutter must be hardened properly without cracking, so that when put into use it will do a great amount of cutting by holding a good cutting edge, and so it is necessary that the toolsmith use great care when heating for hardening. If there is no heating furnace in the shop, and the milling cutter is to be heated for hardening in the coal or open fire, too much care cannot be used.

When heating to harden in the open fire have the coal well charred and the fire plenty large enough. The top of the fire should be perfectly flat and the whole surface a perfectly and very evenly heated mass, place the cutter (if after the shape as **b**, Figure 48) flatway on the top or surface of the fire, now heat very slowly and evenly and turning it over occasionally until it is heated to a very even low cherry red, or just enough to harden, then plunge it into the hardening bath edgeways from a vertical position, allowing it to remain deep in the bath until quite cold, then dry off and polish bright.

To temper the milling cutter, take two round bars of iron about two feet long and just large enough to go through the hole in the center of the milling cutter, put one end of each iron into the fire and heat to a white heat to about two inches back from the end or according to the thickness of the tool. Now take one of the irons (leaving the other in the fire) and place the heated end directly in the center of the milling cutter, holding there until the temper in the teeth has drawn to a dark straw color. If the iron cools to a low heat before the temper is drawn to the exact color use the other iron which was left in the fire to finish drawing the temper, then cool off. Should the milling cutter have very heavy teeth or if it is to cut very hard metal, it will not be necessary to draw any temper.

If the milling cutter be to the shape and size, say 4 inches long and 2½ inches in diameter (or larger sizes) as **a**, Figure 48, a good way to heat for hardening in the open fire is to have a heavy iron pipe about 6 inches long and plenty large enough for the cutter to go inside. A pipe about 1 inch wider than the diameter of the milling cutter will be about right. Place the pipe in the fire and build the coal on top of it, but do not build the fire over either end of the pipe. Instead leave the ends of the pipe open and do not allow the coal to get inside the pipe. By this method an opening is left clear through the fire. Heat the pipe to a bright cherry red the whole length, insert the milling cutter and heat it to the necessary heat to harden, then plunge into the hardening bath from a vertical position. But when heating to harden a milling cutter which has very fine teeth after this method, be very careful not to bruise the fine cutting edges of the teeth against the pipe. It is better to have some arrangement to hold the milling

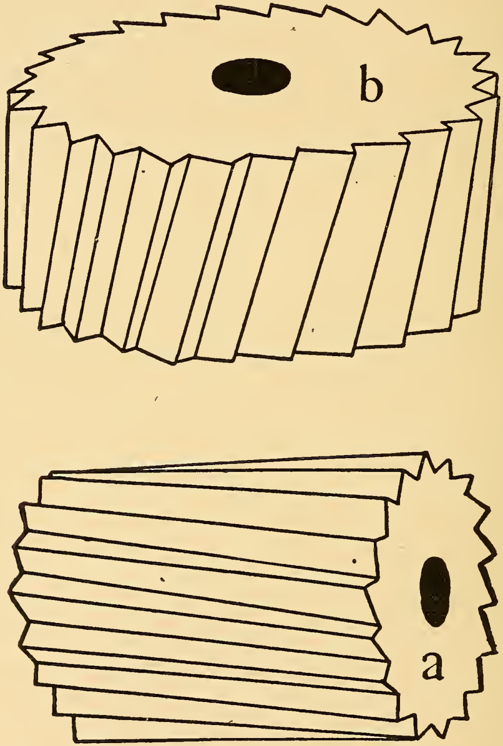


Fig. 48. Plain or ordinary milling cutters.

cutter up from the pipe. An iron bar placed through the center of the cutter with a bearing under each end will keep the cutter from coming in contact with the pipe.

The Use of Asbestos and Clay, When Hardening Milling Cutters and Other Tools.

Very often a milling cutter is made with a thread through the center of the tool which must be kept soft, while the outside or teeth are hardened, and the way this process is accomplished is by the use of asbestos, which is packed well into the inside or thread, but make sure that the outside ends of the thread are well padded over without allowing the asbestos to come in contact with the cutting edges of the teeth of the milling cutter. The asbestos is kept in place while hardening by the use of fine pliable wire, wrapped around the tool. After the hardening has been done and the asbestos taken out from the inside the thread will be quite soft. The reason the thread has remained soft while the teeth are hardened is because the water could not come in contact with the thread when being quenched, on account of the presence of the asbestos.

I have saved a great many delicate and expensive milling cutters from cracking when hardening, by the use of asbestos. Take for example an angle end milling cutter. That is made with a thin or delicate part extended from the main body of the tool. Now, although the tool may be very evenly heated and properly hardened, it is still very liable to crack, and in some cases the thin or extended part will crack off in a solid ring. To stop a milling cutter of this kind from cracking, fill the hollow in the end, as in Figure 49, with asbestos, being careful not to cover any of the cutting edges of the teeth and hold the asbestos in place by the use of fine wire, while hardening. The reason the tool will not crack is, when quenching to harden only the teeth side comes in contact with the water which hardens, while the other side is kept soft as the asbestos keeps the water from coming in contact with the hot steel.

Another example: Take a piece of steel 3 inches long and 1 inch thick, now an inch on each end is to be hardened, while the remaining inch in the center is to be kept soft, and to accomplish this process, wrap the center well with asbestos, keeping it in place by winding some fine wire around it, or instead of using asbestos, wrap the steel around with clay, keeping it in place by the use of a thin piece of sheet metal wound

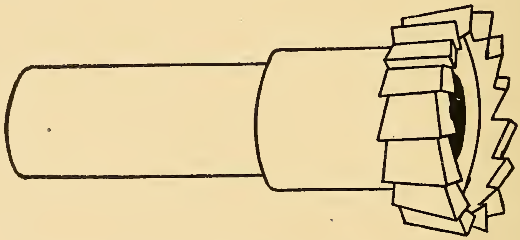


Fig. 49. The angle end milling cutter.

around it, then heat to harden and the results will be as formerly explained.

Hardening Hollow Tools.

When hardening milling cutters as **a**, Figure 48, spring threading dies or any similar tool, always quench them from a vertical or upright position, which will allow the steam and water to come up through the tool and cause the steel to be hardened more evenly. Should the tool be quenched from a horizontal position it will be impossible for the steam to escape, and which will keep the water from coming in contact with the hot steel. Thus when the water is held back by the steam there is a tendency for soft spots in the tool.

As a rule steel workers never pay any attention to the steam when hardening, which is a great mistake, as many tools are partially if not altogether spoiled (more especially if the tools are of a delicate nature) by the great amount of steam which rises as soon as the hot steel comes in contact with the water. Delicate or fine tools of a hollow nature will sometimes warp or even crack, caused by steam and improper methods of quenching.

When hardening a spring threading die, it is not necessary to harden the whole tool, but just far enough back from the thread to allow the temper to be drawn with safety, as indicated by dotted line in Figure 50.

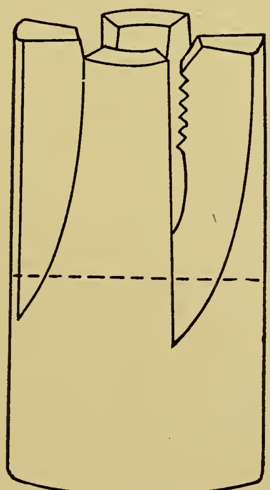


Fig. 50. The spring threading die.

To draw the temper, after being hardened as just mentioned, hold the end or thread part of the tool above the fire and draw the temper very slowly and evenly (by keeping the tool turned around) to a dark straw color.

The Hardening and Tempering of Hob Taps, Stay Bolt Taps and Similar Tools.

In forging, annealing and hardening of long slender tools, such as hob taps, stay bolt taps, etc., too much care cannot be exercised, although as a rule these tools do not have to be forged, as the steel is generally obtained from the manufacturer the right size to allow it to be machined into the tool. However, the steel should be well and evenly annealed, should it come direct from the manufacturer or should it be forged by the toolsmith.

In annealing as well as hardening long slender tools they must be carefully handled when the tool is heated the whole length of itself or it will warp easily, also pack the tool very carefully when annealing so that it will have an equal bearing.

When hardening get the tool to a very even heat, enough to harden the whole length of the thread, and when quenching dip deep in the center of the hardening bath from a perfectly upright position, allowing it to remain in the bath until perfectly cold. Bear in mind that when quenching a long slender tool, any variation from a perfectly upright position will have a tendency to warp the tool. When hardening do not harden the shank, as all that is required to be hardened is the cutting teeth or thread.

To draw the temper, polish bright the grooves in the thread from end to end, have a couple of heavy wrought iron pipes or bands. Heat both in the fire to almost a white heat, then remove one from the fire and put it in a convenient place, place the tap in the heated pipe and draw the tap back and forth to insure a very even temper from end to end. If one pipe is not sufficient to draw the temper, replace with the hot pipe that is in the fire, then cool off the tool. For all kinds of taps draw the temper to a dark straw color. Be sure when drawing the temper not to use too small a pipe, or the extreme fine points of the thread will draw too quickly. For all ordinary taps use a pipe about five inches long and 3 inches inside diameter, while the thickness of the pipe should not be less than ½ an inch or it will cool off too quickly.

Sometimes when hardening a long slender tool only a certain part of it is to be hardened. For example, supposing we have a long slender tool 18 inches long and 1 inch thick. Now 6 inches in the center is to be hardened, while 6 inches at each end is to be kept soft. In a case of this kind take an iron pipe 7 inches long and 2 inches inside diameter, build the pipe into the fire a little above the surface of the forge, and heat the pipe evenly all around and from end to end. Now place the tool through the pipe, having the part which is to be hardened directly in the heated pipe, while the ends which are to be left unhardened will project from each end of the pipe, which will prevent them from becoming hot enough to harden. To keep the tool from warping or bending (while being heated) place something under each end close to the pipe to form a bearing and also to keep the tool in the center of the pipe. If the tool is to be hardened to a very exact length wrap with asbestos at the ends of the part which is to be hardened, as the asbestos will prevent the steel from becoming hardened while being quenched. To illustrate this more clearly, **a a**, Figure 51, represents the asbestos, **b** the part of the tool which is to be hardened and **c c** the unhardened ends.

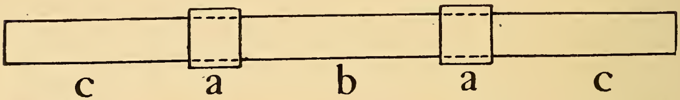


Fig. 51. Illustrating how certain parts of tools are hardened.

Heating Furnaces.

In large shops and factories where tools are made in great quantities, furnaces are used to heat steel, but principally for hardening purposes, and in a great many respects a furnace is superior to an open fire, as steel can be heated in a furnace very evenly and with less danger of it becoming overheated than if heated in an open fire. Tools of a long slender shape, such as stay bolt taps, and tools of a very wide and flat surface such as milling cutters, are best heated in a furnace. Different kinds of fuel are used for heating furnaces. The principal ones used are gas and oil. Gas, however, is preferred, as the furnace can be very readily regulated in order to heat the steel to any degree of temperature. There are many different makes of furnaces and different methods of operating them.

Heated Lead for Hardening Purposes.

The lead bath is extensively used for heating steel when hardening, and has many advantages that a furnace does not possess, as in the lead bath certain parts of tools may be heated in order to harden with ease, and the temper drawn in many ways which could not be accomplished with a furnace.

When heating steel in lead, be sure to use a chemically pure lead, containing as little sulphur as possible. Sometimes when heating in lead there is danger of it sticking to the tool when hardening, but to overcome this difficulty make use of the following compound: Take a pound of powdered cyanide and dissolve it in a gallon of boiling water, afterwards allowing it to cool. Now dip the articles to be hardened in the liquid, remove them and allow to dry before placing them in the lead. The liquid when allowed to dry on the tools will form a moisture on the tools when in the heated lead and prevent the lead from sticking. If lead is allowed to stick to the tool while hardening it will cause soft spots where the lead remains. When heating tools with fine projections have a fine brush and clean off the tool should any lead happen to stick to it.

To obtain the best results when heating in lead, keep the lead stirred up, as it will always naturally be the hottest at the bottom.

A lead bath is preferred to an ordinary heating furnace, as steel heated in lead will not raise a scale; also if the lead is heated to the proper degree it will be impossible to overheat the steel, consequently the steel will be very evenly heated. Should there be a great many small tools to harden at once, place them in a heavy wire basket or sieve and lower into the lead; after being heated they may be all quenched together.

Boilermakers' Tools.

Boilermakers' tools, although not so many in number or of so complicated a nature as machinists' tools, should be well understood in order to forge, harden and temper them successfully. The principal tools used by boilermakers are beading tools, punches and dies, rivet snaps, flue expanders, drifts, calking tools and chisels.

The Beading Tool.

This is a tool which the average toolsmith does not understand, especially the hardening and tempering. Beading tools are principally made from ⅞-inch octagon steel of 75 point carbon. After forging, then filing or grinding to the proper shape as in Figure 52,

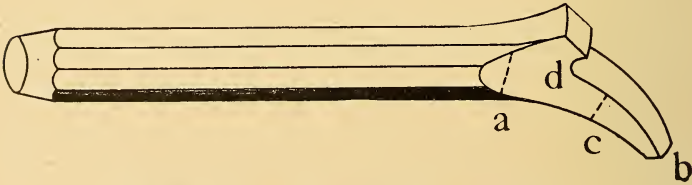


Fig. 52. Correct shape of beading tool.

harden as indicated, between the dotted lines, then temper to a light blue. A great many tool-dressers harden the whole end of the tool from **a** to **b**, and the results in a great many such cases are that the tool breaks off at **c**. Now I wish to say to the average toolsmith that the point acts only as a guide for the tool and it should be kept soft, as only the hollow in the tool at **d** does the work and only the part that requires to be hardened and tempered.

When a great many of these tools have to be hardened and tempered at one time, a good way to do this work is by having a very small fire, just large enough to heat the part to be hardened. The fire should not be any wider than 1½ inches across the surface, and the way to build a fire for this purpose is, after the fire is nicely started build up with wet coal, with the exception of a very small place exactly in the center, which should be kept well filled up with fine crushed coke or charred coal, keep the blast blowing gently as the fire is being built up. By this method a fire may be made very small.

When only a few beading tools are to be hardened at one time and it is necessary to heat them in the ordinary fire, keep the point of the tool from **b** to **c** well cooled off in water. Do not allow it to become a white heat before cooling it off. Cool it often, not allowing it to become hotter than a low dull red. In this manner the point will be kept soft, while the part between **a** and **c** is heated to a cherry red so as to harden. When quenching dip in the hardening bath down as far as **a**. To draw the temper let it run down very slowly, or what is better, draw the temper over the fire. To obtain the best results from tempering the whole space between the dotted lines should show a light blue.

Punches and Dies.

When hardening punches and dies (for perforating boiler plate or iron) and when a great many of these tools are to be hardened at one time, there is nothing better to heat them in than heated lead, but as most of shops are without this convenience likewise a heating furnace, we must resort to the open fire. However, speed will be acquired and time saved when hardening and tempering in large numbers if the following method is put into practice: Have the fire large and flat and well heated across the surface. Now place a plate of iron or boiler plate which should be about 9 inches in width, directly on top of the fire, bank the coal up around the edges of the plate to about 3 inches high and in the form of a circle, leaving the circle or open space on the plate about 5 or 6 inches across. Now place as many punches or dies on the hot plate inside the circle with the cutting edge up as is convenient. Then place another plate over them, allowing it to rest on the bank of coal which will form a furnace. Turn on the blast slowly and as the punches or dies become hot enough to harden, quench them and replace with others until all are hardened.

To draw the temper, polish bright and place them on a hot place with the cutting edge upwards and allow to remain until the necessary color appears on the cutting edge. Then cool off. For a punch allow the temper to draw to a light blue. For a die a dark straw will be good. When heating small punches and dies for hardening as Figure 53, heat the whole tool and quench from a vertical position.

Flue Expanders.

When hardening long flue expanders pins, as Figure 54, follow the instructions as given in hardening hob taps, stay bolt taps, etc., but harden the whole length of the tool from **a** to **b**, while the temper must be drawn to a dark blue if the right kind of steel is used, which should be about 75 points carbon, likewise all small parts of flue expanders should be tempered to a dark blue.

All small parts of flue expanders may be heated to harden, by placing them on a hot plate of iron. The plate of iron being placed directly on the surface of the fire and heated to a light yellow, a slight hollow in

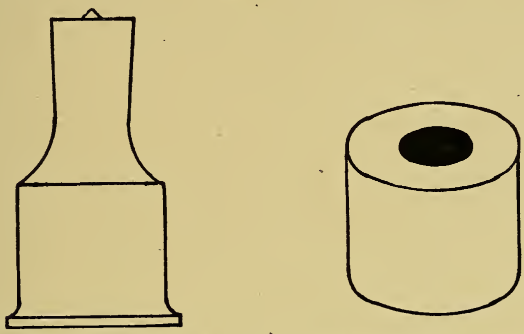


Fig. 53. Punch and die for perforating boiler plate, iron, etc.

the iron plate will be best, which will keep the small parts together, and also keep them from rolling off the plate, but bear in mind to occasionally turn the tools over in order that they will be heated evenly. To draw the temper can be done somewhat after the same

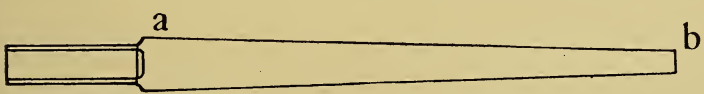


Fig. 54. The expander pin.

method as heating to harden, but do not have the plate of iron nearly so hot, as a low dull red heat in the plate will be sufficient to draw the temper. However, keep the tools well turned over in order that they will be evenly tempered.

Drifts, Rivet Snaps, Calking Tools and Chisels.

When making a boilermaker's drift it must not be hardened or tempered or it will break easily. It should be forged to a long gradual taper very round and smooth. For a half inch drift take a piece of 7/8 round or octagon steel, draw it down to 1/4 of an inch at the small end and tapering back to 7/8 at the large end, while the length is 5½ inches.

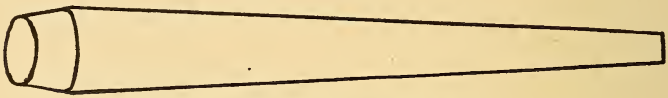


Fig. 55. The boilermaker's drift.

Rivet snaps, which are used for rounding the heads of rivets when riveting, are made from 7/8 octagon steel. The end as marked a, Figure 56, is made by upsetting the steel, while the hollow in the end illustrated by dotted lines is generally made by a machinist by turning it to shape in the lathe. Harden and temper it after the fashion of a cold chisel, draw the temper evenly to a light blue by gradually and slowly turning the tool around above the fire.

Calking tools are made somewhat like a cold chisel, with the exception that the bevel of a calking tool is on one side only, the other side being perfectly straight with the body of the tool.

Boilermakers' chisels will be found mentioned in another part of this book.

Hardening Shear Blades.

When hardening blades to shear boiler plate or iron, heat the cutting edge only (say for 1 inch back) by drawing back and forth through the fire, making sure to get a very even heat from end to end, then quench in the hardening bath from a vertical position and cool off entirely. When tempering, polish bright and draw the temper to a purple by moving back and forth over the fire or on a hot plate of iron, being careful to get a very even temper, then cool off. Sometimes, although seldom a shear blade is made with two cutting edges instead of one, so in a case of this kind, heat the whole tool evenly from end to end when hardening, afterwards tempering as already mentioned.

Fig. 56. The rivet snap.

Fig. 57. The calking tool.

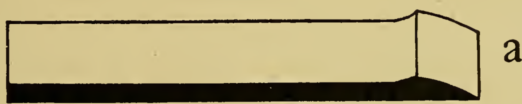
CHAPTER VI.

Woodworkers' and carpenters' tools.

One of the greatest secrets of success connected with woodworkers' tools, is to be able to make them so that they will hold a keen cutting edge. Woodworkers' tools are made now almost entirely of steel, with a few exceptions, such as a carpenter's chisel, which is made from iron and laid with steel. But when laying a carpenter's chisel or any similar tool don't select any piece of scrap steel that might chance to be handy, such as an old file because it is of a flat shape, but get the best steel of about 75 points carbon. If there is no flat piece of good steel in the shop near the shape of the chisel, forge a piece of octagon down flat to near the shape the chisel is to be, as it is always better to do a little hard work; spend a little extra time and produce a good tool, in order to get a good reputation.

Laying a Carpenter's Chisel.

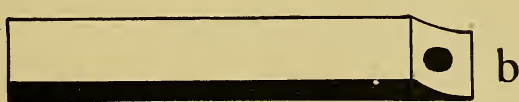
When making the weld upset the iron and steel in order to have plenty of stock, and when forging the scarf for a separate weld have it a little rounding as **a**, Figure 58, but do not leave any hollows in the scarf, as **b**, Figure 58, for dirt and slag to get into. Before taking the welding heat prepare the fire, by having the coal well charred and the gas and sulphur taken out. Now heat the iron to a raw heat and take a good borax heat on the steel, after drawing from the fire (before placing together to make the weld), strike the ends on the anvil to knock off all foreign substance. When hammering to make the weld strike the first two or three blows lightly, then with heavy blows, making it a point to finish the weld by striking on the flat side when at a low heat. Also bear in mind that when hammering to make the weld strike the first few blows di-



The correct method.

rectly in the center, which will weld the center first and force all slag and foreign matter out. Otherwise if the ends are welded first the slag will be forced into the center and cannot get out, which would keep the parts from uniting or welding.

After welding to finish the chisel follow the direc-



The wrong method.

Fig. 58. Illustrating methods of scarfing steel for separate welding.

tions as mentioned in making a cold chisel, after hardening draw the temper to a dark blue. These directions will apply to all wood chisels, plane bits, etc.

When making or repairing any tool with a beveled cutting edge, such as a framing chisel, Figure 59, forge the bevel to shape as indicated by **a**, which will save a great amount of filing or grinding, and the tool will be just as good if it is hammered when at a low heat on the flat and beveled surfaces only. Harden and temper all ordinary woodworkers' chisels, at least 1½ inches back from the cutting edge.

Fig. 59. The framing chisel.

The Screw Driver.

A good screw driver is a tool which is prized by almost every mechanic who uses one, but more especially by woodworkers, and there are very few blacksmiths or tool dressers capable of making one to give perfect satisfaction, as the screw driver will generally break or twist when coming in contact with hard screw driving.

When making one select good steel of 75 points carbon. After it is forged to the correct shape for an ordinary screw driver as Figure 60, strike it a few good

Fig. 60. Correct shape of ordinary screw driver without handle.

blows on each flat side of the screw driving edge while at a low heat. Then harden and allow the temper to draw to a grey, cool off and you will have a screw driver that will give unlimited satisfaction.

How to Make a Draw Knife.

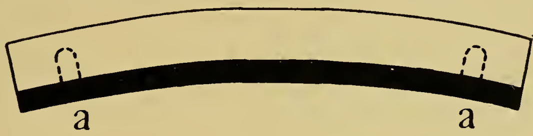
A draw knife is a very handy tool for woodworkers, and is also used a great deal in general blacksmith shops. Although draw knives are made almost exclusively in large tool factories, they are as a rule inferior to one made properly by hand and from good steel. Draw knives vary in shape and size according to the work they are to do, but also a great deal depends on the fancy of the woodworker who is to use it.

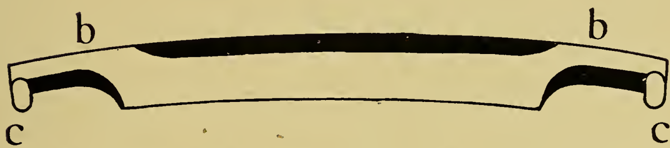
To make a draw knife for ordinary use and which will answer mostly all purposes take a piece of steel of 75 points carbon, 9 inches long, 3/8 thick and 7/8 wide. To forge, first of all heat and bend the steel edgewise in a circular shape as in Figure 61, then draw down the cutting edge from the inside of the bend to within an inch of each end, indicated by **a a**, which will bring the knife back straight again. Now fuller in as illustrated by dotted lines **a**, **a**, then draw down the ends to form the shanks as **b**, **b**. Now draw the bevel on the back of the knife which will crook the knife edgewise again, but it does not signify, as the knife will come straight again before it is finished. Now weld on pieces to the shanks to form the handles, but instead of welding on straight, then bending, take a piece of small round iron 1/4 thick, upset the end of the iron and weld as illustrated at **c**, **c**. After welding, bend the handles up a little at right angles in order to allow the draw knife to be finished (as it must be done in the open fire). To finish the knife, heat the whole length of the cutting edge of the knife to a low dull red, then hammer the whole flat surface of the cutting edge from end to end, then turn over the knife and hammer the other side the same way. Now take another very low heat as before, but instead of hammering directly on the cutting edge, hammer in the center of the blade and on both sides the same. After hammering the knife has come straight again, but if it is not exactly straight and instead there is a little fullness in the cutting edge it will be better than if perfectly straight. When making an ordinary draw knife have the under side very flat.

To harden the draw knife, have the fire wide or in a long shape, with the coal well charred and loose. Place the knife in the fire with the cutting edge downwards, turn the blast on very slow and move the knife back and forth through the fire to insure a very even heat the full length of the cutting edge. Then quench by plunging into the hardening bath with the cutting edge downwards, and cool off entirely. If the knife was well forged and hammered evenly on both sides the knife will come out of the hardening bath perfectly straight, but otherwise there will be a crook in it flatwise. However, supposing there is a crook in it, polish one side bright and draw the temper to a light blue by holding the knife flatwise over the fire and moving back and forth in order to get a very even temper, "but before cooling off" place the draw knife on the anvil and take the crook out by striking it with the hammer. The reason the crook is taken out so easy is because only two-thirds of the knife was hardened, the back of the knife remaining unhardened, which along with the heat being in the knife, allows the hardened and tempered part to bend without springing back, now cool off and the knife is ready to grind.

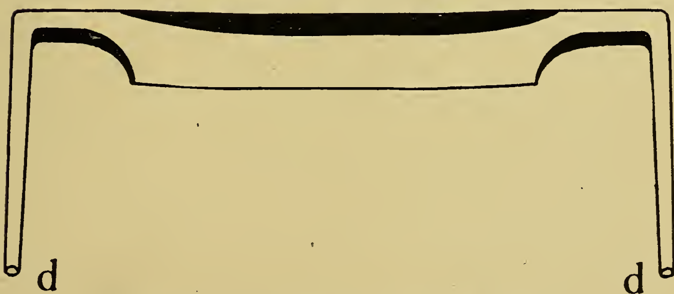
After the tempering is done, to bend the handles to shape, heat to a dull red, being careful not to draw the temper in the main body of the knife. This will be overcome if the body of the knife is placed in water or by keeping it cool with a wet rag or sponge.

Piece of steel bent, to make draw knife.





Illustrating, cutting edge drawn, back beveled and shanks forged.



Draw knife completed with handles welded on.

Fig. 61. Showing how to make a draw knife.

To hold the handles on a draw knife, generally the shanks are riveted at **d**, **d**, but what is better, cut a thread on the ends of the shanks and fasten the handles on by the use of a small nut and washer.

CHAPTER VII.

Stonecutters' tools for granite and marble.

The making and sharpening of stonecutters' tools is a very important branch of the toolsmith's art, and first class tool dressers of stonecutters' tools are scarce. Although the greatest obstacle to be overcome in connection with stonecutters' tools, after having a thorough knowledge as regards the nature of steel, is to know the shape and what temper to give. But otherwise the steel is worked practically the same as in making a cold chisel, or any other flat tool which is to have a cutting edge.

There are many branches to the stonecutter's trade, which varies according to the class of stone or rock the stonecutter is to cut or work on, as some classes of stone are much harder than others, consequently there is a great difference in the ways of cutting different classes of stone, and also as much difference in the shape and temper of the tools. The most common classes of stone which are cut and used for building purposes are granite, marble, limestone and sandstone.

Granite Cutters' Tools.

The tools principally used to cut granite are points, chisels, bush hammers, mash hammers, granite hammers, bull sets and bull chisels.

In Fig. 62 is illustrated the correct shape of a point and chisel, which are drawn down very thin at the extreme cutting edge but with a very short taper. When dressing chisels, keep a very coarse file on hand to straighten the cutting edge after hammering. Points and chisels are made as a rule from 7/8 octagon steel, but points will be better if made from 7/8 square, as a point made from square steel will be held much easier to the stone, and will not twist round in the hand so easy as if made from octagon steel.

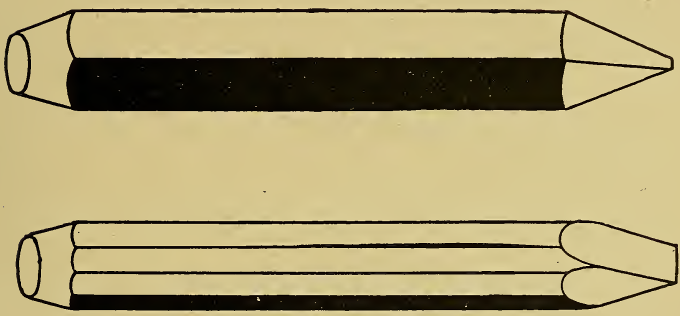


Fig. 62. Correct shape of granite point and chisel.

When hardening points and chisels, it is not necessary to heat them hot enough to harden any farther back than 1/2 inch, but be careful when heating so as not to get the extreme thin cutting edge too hot. When quenching to harden dip deep into the hardening bath to at least one inch, so that the temper will draw very slowly to a dark straw, which is good for all ordinary granite tools. But if the granite is exceptionally hard, draw no temper on the chisels.

The Granite Drill.

Fig. 63 illustrates front and side views of a granite hand drill, which are used almost entirely in quarrying granite, and is made from ¾ octagon steel. The shank of the drill is drawn down to ½ inch round and 4½ inches long. The bit is forged to a square or diamond flat point, being left 1-16 thick on the cutting edge and ⅝ wide, which gives the drill a good clearance and enables it to cut much better and faster, and will not get fast in the hole. Harden and temper as a point or chisel already mentioned. A drill forged,

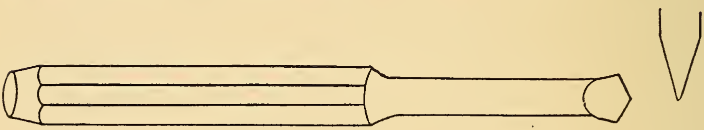


Fig. 63. The granite hand drill, illustrating flat and side views of the bit.

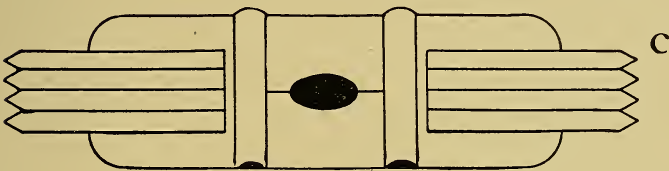
hammered, hardened and tempered properly, will drill two holes 3½ inches deep. I have had them put in as many as four holes 3½ inches deep, but a drill improperly hardened or overheated will not put in one hole, besides tiring the driller much quicker.

Bull Sets and Bull Chisels.

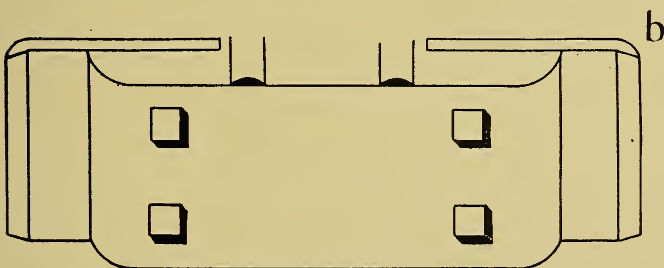
Bull sets and chisels are dressed and hardened as a stone hammer, with the exception that only one end is dressed, the other end being a chisel head which is left unhardened for the sledge to strike upon. A bull set is made the same shape as the face end of a stone hammer. The bull chisel resembles the flat or tapered end. Stone hammers will be found fully explained and illustrated in another chapter of this book.

The Granite Bush Hammer.

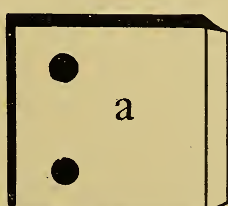
The cutting part of a granite bush hammer is comprised of thin flat blades, which are held in place by



Front view.



Side view.



The blade.

Fig. 64. The granite bush hammer.

two bolts going through the blades and also through the hammer. The blades are taken out to sharpen, as shown at **a**, Fig. 64, the cutting edge of the blade, which consists of a very short level from each side, is forged or hammered to sharpen, while the corners are left somewhat rounding, which keeps them from breaking off, as shown in figure at **b**. When sharpening be careful to keep the blades perfectly straight and have the cutting edge beveled equally from both sides, also bear in mind that the blades should all be exactly the same length after being sharpened and replaced in the hammer, as illustrated by dotted line at **c**, otherwise should the blades be uneven the hammer will not do good work, while the blades will have a tendency to break at the cutting edge.

In order to make the corners rounding when sharpening, strike a blow on the corners edgewise before hammering on the beveled surface. Then the steel will be refined and the cutting edge sharpened by striking every blow on the beveled surface. After hammering, file the edges straight with a coarse file.

As the cutting edge of the blade is very thin and wide, be very careful when heating to harden by having a very even heat. Heat hot enough to harden about ¾ of an inch back from the cutting edge, but when quenching dip the blade to at least 1 inch deep, then polish one side bright and draw the temper over the fire, moving the blade sideways back and forth to insure a very even temper, draw to a light straw, then cool off.

Some bush hammers differ slightly from others, owing to the number of blades they contain. The one illustrated in Fig. 64 is considered a coarse cutting hammer.

The Granite Hammer.

A granite hammer resembles an ordinary stone hammer, with the exception that both ends of a granite hammer is drawn down very tapering to an extreme sharp cutting edge, as Fig. 65. After hardening, temper to a light straw.

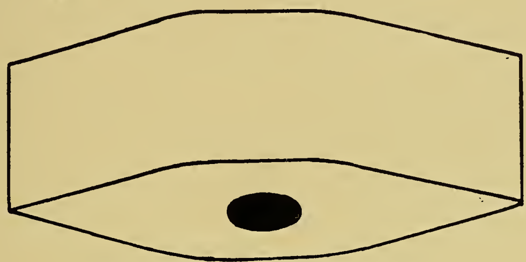


Fig. 65. The granite hammer.

Granite Cutters' Mash Hammer.

When making a granite cutter's mash hammer, use good steel of 75 point carbon, and 1¾ inches square. When forging, do not put in a large oval eye as other hammers, but instead punch a small round eye not exceeding ¾ of an inch in diameter, which is about the right size. The ends of a mash hammer are beveled down from the eye on the top and sides, the bottom side is left perfectly flat. The face at each end is also on a bevel, which should be dressed a little full in the center and the corners left very rounding. Harden both ends as mentioned in making hammers in another chapter of this book, but after proper hardening it is not necessary to draw any temper as there are no sharp corners to break off. Fig. 66 illustrates the correct shape of a mash hammer.

The Granite Tool Sharpener's Hammer and Anvil Stake.

When sharpening granite tools, the toolsmith should use a bevel face hammer and anvil stake, as Figures

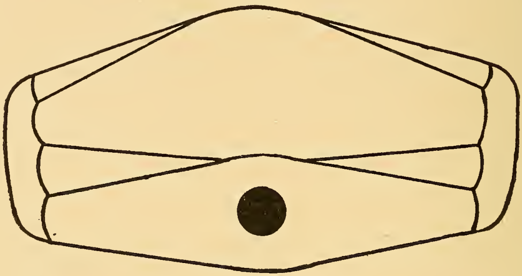


Fig. 66. Granite cutters' mash hammer.

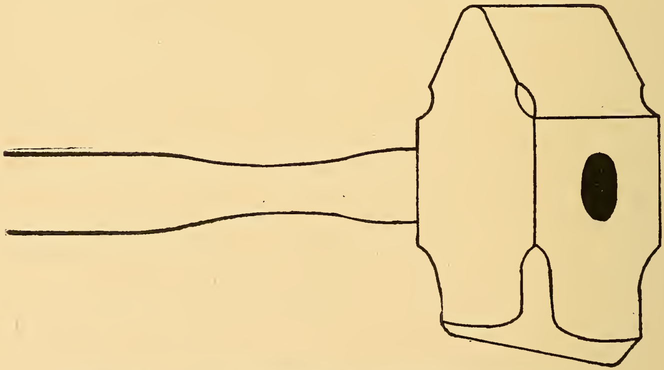


Fig. 67. The granite tool sharpeners' hammer.

67 and 68. These tools are a great advantage over an ordinary flat face hammer and the plain anvil, and after a little practice in use the work will be performed much easier, quicker and neater.

The stake sits in the square hole of the anvil and should be kept perfectly firm, by driving a flat key through the shank illustrated at **b**, the shank being made long enough to project through the anvil 1½ inches. Harden the face surface of the stake all over but not very deep. Be careful when heating to harden

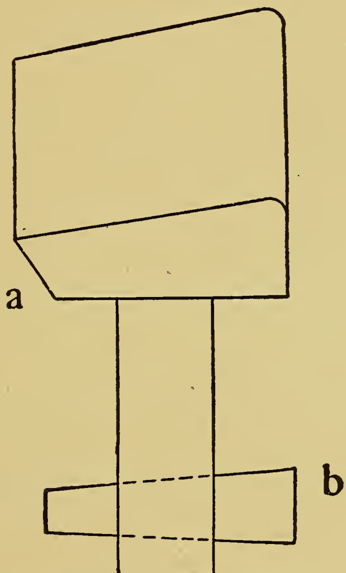


Fig. 68. The anvil stake.

so as to get a very even heat in order to harden the center of the face, and do not heat too quick or the corners will become overheated. The beveled front side of the stake at **a** will be found much better than if made perfectly straight for cutting off the ends of broken tools and uneven edges.

To make a granite tool sharpener's hammer, use steel 1¾ inches square. To harden and temper follow the directions given in "Hardening and tempering a hammer" in another chapter.

Marble Cutters' Tools.

Tools for cutting marble are in a great many ways the same as those used to cut granite, with the exception that the temper is left a little harder, say, a very

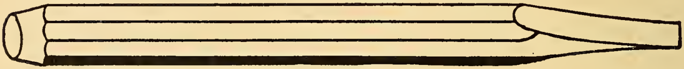


Fig. 69. Marble lettering tool.

light straw. Lettering tools are drawn out very thin, as Fig. 69, but owing to the thinness be very careful when heating, and make sure when dressing to always strike the last few blows on the flat side only, when at

Fig. 70. Marble tooth chisel.

a very low heat. Tooth or ordinary plain chisels are not drawn out so thin as lettering tools. When making or dressing tooth chisels, the teeth are filed in after the hammering is done.

CHAPTER VIII.

Stone cutters' tools continued, for limestone and sandstone—Stone lathe and planer tools.

Limestone Cutters' Tools.

As limestone is of a soft nature, the tools used to cut it are of a very different shape and temper to those used for hard stone such as granite or marble. In cutting soft stone of any description wooden mallets are used, consequently the heads of the tools are made broad and a little rounding, so as not to cut or bruise the mallet, as illustrated in Fig. 71. This class of tools is known as "mallet headed tools."

The tools used principally for cutting limestone are plain and tooth chisels, points, pitching tools, hand and ball drills, tooth axes and bush hammers. When making any of these tools use steel of 75 points carbon.

Plain and Tooth Chisels and Points.

Chisels and points are made chiefly from ¾ octagon steel. When making chisels, if the chisel is to be narrow forge the head first, but should the chisel necessarily have to be made wide, the chisel end should be forged first, as when forging wide chisels the steel will have to be upset (according to the width of the chisel) before drawing down to a thin cutting edge. The teeth are put in tooth chisels with a punch machine, after the hammering is done on the flat surface, and then filed to an extreme sharp point.

When hardening chisels be careful to get a very even heat all along the cutting edge and dip in the hardening bath not less than one inch; polish bright and draw the temper to a very pale blue, which is the right temper for all limestone tools.

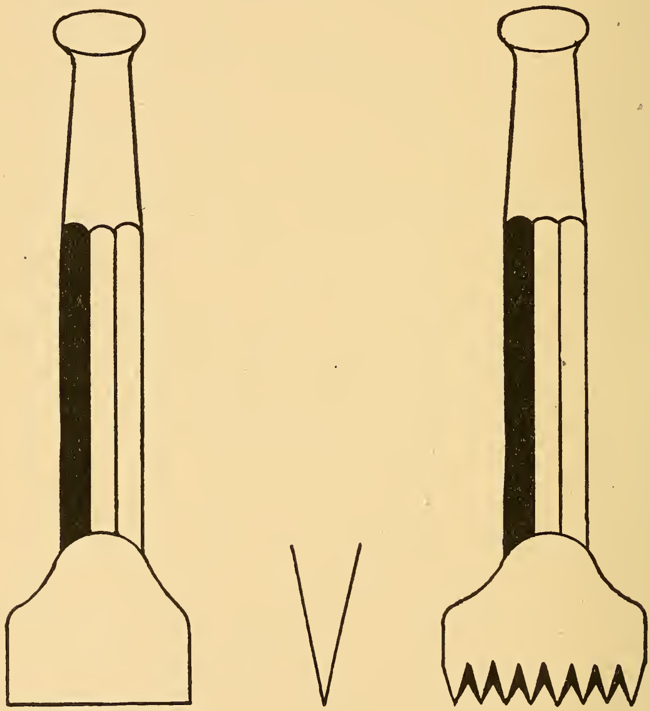


Fig. 71. Plain and tooth chisels for limestone.

Points are drawn down to almost a square point. When hardening dip deep into the bath, and draw the temper so that it may be seen at least ⅝ of an inch back from the cutting edge, otherwise should the temper run down very fast so that only the extreme point becomes tempered, the point will be easily bent and broken.

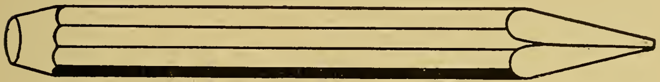


Fig. 72. The limestone point.

Pitching Tool.

A pitching tool is made from one inch octagon steel, but to form the cutting edge the steel must be upset a great deal. The cutting edge of a pitching tool for all soft stone, should be slightly beveled as indicated by **a**, Fig. 73. The cutting edge of a granite pitching tool will be best if left perfectly straight.

Fig. 73. The pitching tool.

Hand and Ball Drills.

Hand drills for limestone are made on the same principle as hand drills for granite (see Fig. 63) with the exception that the bit on a drill for limestone is drawn out much thinner and to a sharp cutting edge, the cutting edge being made slightly rounding.

Ball drills are made by taking a bar of iron about 5 feet long and 1¼ inches in diameter, then welding a piece of ¾ octagon cast steel at each end, afterwards drawing out as a hand drill, thus having a drill at each end. But bear in mind that the drill on one end should be ¾, the other ⅝. A ball drill is used for drilling by raising it up, then allowing it to drop down from a vertical position, the larger drill on one end being to start the hole, and the smaller one at the opposite end being used to finish. Thus the large drill gives clearance to the smaller drill, which prevents it from sticking in the hole. After hardening, draw the temper to a pale blue.

The Tooth Axe.

The tooth axe is a tool used a great deal by limestone cutters, and which has the cutting teeth at each end as illustrated in Fig. 74. To make a tooth axe

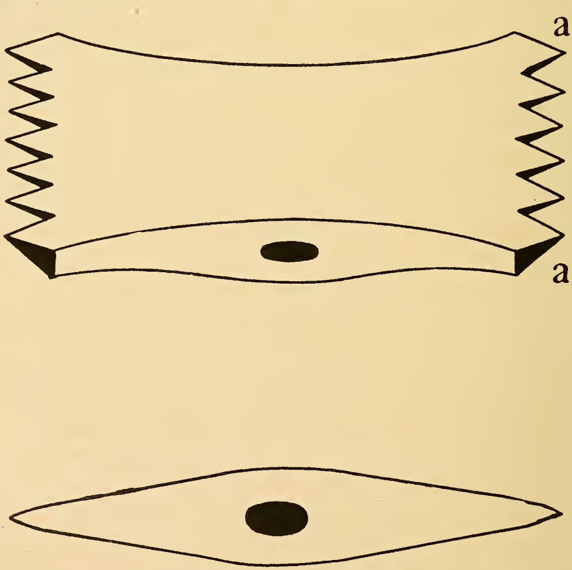


Fig. 74. Side and end views of tooth axe.

take a piece of steel 2½ by 1½ and 5½ inches long. After the hole is punched, when drawing down the ends allow the steel to gradually widen out towards the cutting edge. Draw down both ends to a flat and sharp cutting edge before undertaking to cut in the teeth.

Before cutting in the teeth, have a block of wood or some other convenience to rest one end of the tooth axe on while cutting the teeth in the opposite end and so keep the cutting edges of the tooth axe from becoming bent or bruised up. As some tooth axes have more teeth in one end than the other, measure off and nick in a little with a sharp cold chisel where the teeth have to be cut in. Now take a deep red heat and cut in with a thin splitting chisel as deep as is necessary at the nicks as measured off, afterwards cutting the pieces out at right and left angles and the shape of the teeth will be formed. But bear in mind when cutting the teeth make sure that the outside teeth, as **a a**, Fig. 74, are a little the largest or heaviest, which will add strength and keep them from breaking off (owing to the extra hard usage) when in use.

Finish at a low heat by placing a flatter on the flat surface and let the helper strike it a few good blows, which will straighten the teeth and add strength and tenacity to the steel, allow the tooth axe to cool off, then file off all roughness between the teeth by using a three-cornered file, also file the teeth to an extreme sharp point, making sure that all the teeth are in a straight line and exactly the same length.

When hardening, heat all the teeth evenly, being careful not to overheat the corner or outside teeth, dip to quench in the bath to about 1¼ inches deep, and draw the temper over the fire, moving back and forth in a sideward motion to insure a very even pale blue temper.

The Limestone Bush Hammer.

To make a bush hammer that is to give good satisfaction, requires great skill and care in forging, hardening and tempering, but if these instructions are followed closely good results will follow. To make one, use steel 2 inches square and 7 inches long; after punching the hole, which should be small and almost

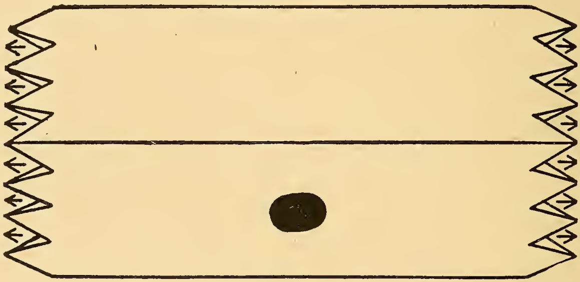


Fig. 75. The limestone bush hammer.

round (say ¾ in. diameter), now before cutting in the teeth have the end of the hammer perfectly square and flat, and to form the outside of the teeth the hammer should be beveled equally on all four sides as shown in Fig. 76. But remember that after the end of the hammer is forged, and the teeth are to be cut in, never heat above a bright cherry red, otherwise, if a very high heat is used when cutting in the teeth, the teeth will not hold a good cutting edge, as there is no way to refine the steel.

Bush hammers differ somewhat, by having different numbers of teeth, which range from 16 teeth or 4 cuts to 144 teeth or 12 cuts. The one illustrated represents a 4-cut hammer. To put in the teeth first measure off into squares according to the number of teeth required, and nick in with a sharp edged cold chisel; now heat the hammer to a cherry red and proceed to cut in the teeth by cutting in at the nicks with a thick edge chisel, which will form the point of the teeth. Heat again; this time take a very thin edged splitting chisel and cut in to the depth required, which will vary according to the size of the teeth, but for a 4-cut hammer, cut in to 5/8 of an inch deep. The first end of the hammer may have the teeth cut in by letting

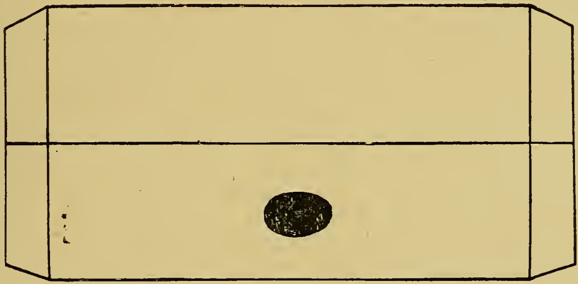


Fig. 76. Illustrating how bush hammer is forged before cutting in the teeth.

the opposite end rest on the anvil, but to cut the teeth in the other end the hammer will have to be placed on a block of wood or some other convenience, which will not interfere with the teeth.

After the teeth have been cut in they will have to be filed to a sharp square point by using a flat feather-edge file, thus, ◆. A file of this description will go much deeper into the cuts than an ordinary three-cornered file. When filing be careful to keep all the teeth the same length. In large up-to-date tool shops the teeth are put in by the use of a planer, but in small or ordinary shops the teeth must be put in by the use of a chisel and file.

When hardening, heat to a very even heat just enough to harden, being careful that the corners do not become overheated by heating too fast, and also watch the extreme points of the teeth for fear they become overheated. Although only the teeth are necessary to be hardened, it is always best to have plenty of heat back of the teeth in the main body of the hammer (which should not be hot enough to harden, and so should not exceed a low blood red), which is necessary to drive down the temper, as the temper on the inside teeth cannot be drawn over the fire unless extreme great care is exercised. After hardening by dipping vertically in the bath to the depth of almost one inch, moving up and down a little at the same time in order to soften gradually, then polish up bright as well as possible and allow the temper to run down in the teeth to a very light blue.

When tempering bush hammers, as a rule, the teeth in the centre are apt to draw the temper first, while the corner teeth are yet hard. To overcome this difficulty, take a small piece of wet rag or sponge fastened to a piece of wire, commonly known as a swab, and as soon as the temper in the centre teeth draws to a light blue, place the wet swab directly on the tempered part. This will hold the temper in check in the centre teeth until the outside teeth draw to the proper temper.

Harden and temper both ends of the hammer the same, but when hardening and tempering the last end be careful not to draw the temper in the opposite end (which is already hardened and tempered), which can be overcome by dipping in water occasionally.

Sandstone Cutters' Tools.

Sandstone, although of a soft nature, differs somewhat from limestone, it being of a very sandy composition, while limestone is in the nature of very hard clay. Tools properly made for limestone will remain sharp a long time, but tools for sandstone wear away very fast. The tools used to cut sandstone are practically the same as those for cutting limestone, the points and plain chisels being the same, but tooth chisels differ somewhat as the teeth are left flat, as shown in Fig. 77, while tooth chisels for limestone are filed to a

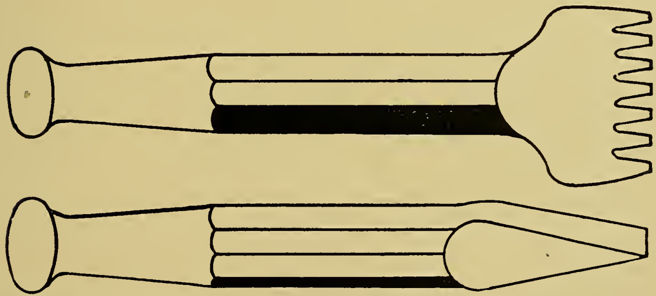


Fig. 77. Showing sandstone tooth chisel and splitting tool.

sharp point. The teeth in sandstone tooth chisels are put in with a punch machine after the last hammering is done.

When dressing plain or tooth chisels for sandstone, be careful to leave them a little rounding in the cutting edge, as these tools when cutting sandstone are naturally inclined to become hollowing in the centre, and more especially in wide chisels. When tempering sandstone tools let the temper draw to a light blue, but when tempering very wide chisels be careful and do not allow the temper to run out at the centre while the corners are at a straw color, as all wide tools of an irregular shape (especially when not being hardened very far back from the cutting edge by not being dipped very deep in the hardening bath) have a tendency to draw the temper in the centre first, so have a small swab which consists of a small piece of wet rag or sponge attached to the end of a piece of wire, and when the temper in the centre of the chisel reaches a light blue, press the wet swab directly against it, which will hold the temper in check until the corners are drawn to the proper color.

Stone Carvers' Tools.

All stone carvers' tools are made very thin and fine, but as the blows that fall upon them are exceedingly light it is not necessary to draw any temper, as they will stand and give good results, if properly hammered and hardened.

Polishing Board for Stone Cutters' Tools.

When tempering stone cutters' tools and a great many at one time, have a short piece of board nailed or fastened in a convenient place close to the forge, and have some fine clean sand to put on the board. The board, if beveled a little upwards, will hold the sand on it much better than if fastened perfectly level. After hardening, the tools are brightened while in the hand or tongs by simply rubbing on the sand across the board.

How to Forge Mallet Head Tools.

To forge or make mallet head tools, they should be first upset a little, afterwards being fullered in, then drawn out. Then swage to shape by using tools as shown in Fig. 78.

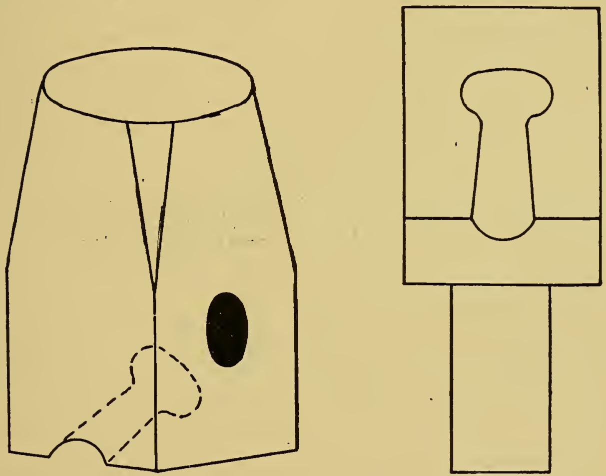


Fig. 78. Top and bottom swage for making mallet head tools.

Punching Teeth in Stone Cutters' Tools.

There are different kinds of punch machines used in performing this work, which are operated by an upright, side or foot lever, and all will do good work as a rule if the punch and die are made properly. The correct shape of these tools are shown in Fig. 79, which illustrates both die and punch made with a bevel. This style of punch and die will punch the teeth very easy and the punch will not break so easy and will keep the chisel straight when punching in the teeth. The opening in the die at **a** should be a little larger on the under side, which will act as clearance. The cutting edge of the punch should fit the opening very closely, it being a little thinner back from the cutting edge in order that it will move up and down through the opening "in the die" with ease. The beveled cut-

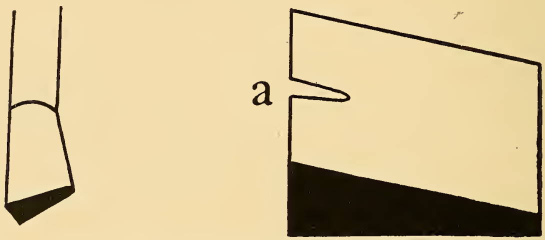


Fig. 79. **Punch and die for teeth punching machines.**

ting edge of the punch allows it to punch the teeth by a gradual cut, and which works much easier than if it was made with a perfectly straight cutting edge.

The teeth will punch best when the steel is just a little warm. When punching be careful to hold the chisel perfectly level on the beveled surface of the die, otherwise the chisel will bend. In cases where the teeth bend after punching, do not undertake to straighten again when cold, as that will take out all the toughness and tenacity from the steel (that was put in the steel when hammering at a low heat) and the chisel or the teeth will break very easy when in use, but when straightening after being punched heat the chisel to a low heat.

Harden the punch as any ordinary flat tool and draw the temper to a dark blue. To harden the die heat the whole tool evenly enough to harden, then cool off entirely, afterwards drawing the temper over the fire or on a piece of heated flat iron. Draw the temper to a dark straw.

Lathe and Planer Tools for Cutting Soft Stone.

In large and up-to-date stone yards, a great amount of stonecutting is done by machinery, and which brings into use "stone lathe and planer tools." There are a great many tools of this description used, and almost every one is of a different shape, varying according to the work that is to be done. Some of these tools are made from heavy steel, as finishing tools shown in Fig. 80, which are made from 1 by 4-inch flat steel,

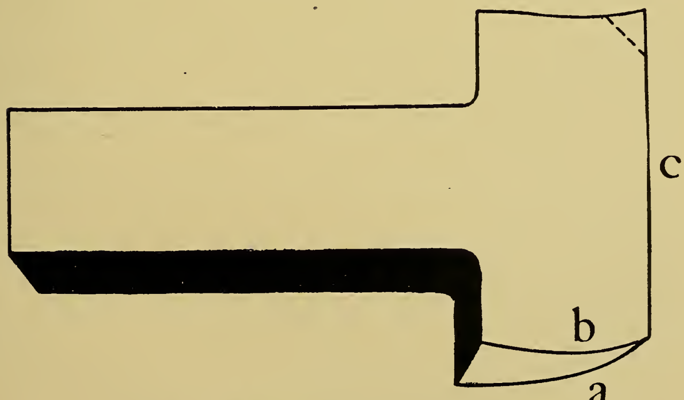


Fig. 80. Finishing tool for stone planer.

while the cutting edge is about 6 inches wide. To make a finishing tool as illustrated, the steel will have to be upset, then drawn or flattened out until it is the proper size. Heat to a good yellow heat when forging. The cutting edge is drawn down on a bevel principally from one side, as illustrated by **a** in figure, leaving the other side, **b**, perfectly flat. After the cutting edge is drawn out (as just mentioned), then hammered at a low heat to refine the steel, the cutting edge at **c** should be bent up a little from the flat side, which will enable the tool to be cut much better. Roughing tools illustrated in Fig. 81 are made some-

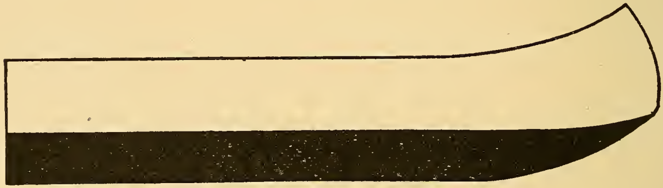


Fig. 81. Roughing tool for stone planer.

what after the same method, but from much smaller steel; also the cutting edge of a roughing tool is made rounding. Moulding tools are forged as near to the correct shape as possible, afterwards being ground.

To harden, heat the cutting edge about three-fourths of an inch back, enough to harden, according to the shape, but dip deep in the bath and draw the temper to a light straw color. For finishing tools, it is not necessary to draw any temper with the exception of the extreme corners, as indicated by dotted line of figure, which should be drawn to a light straw by holding over the fire.

Dressing Tools with the Cutting Edge Beveled from One Side Only.

When dressing tools of this description a great difficulty is to be contended with, such as hammering or forging equally from both sides. Most blacksmiths and tool dressers have a great tendency to hammer on the beveled side only, which is a great mistake. Take, for example, stone planer tools as illustrated in Figs. 80 and 81, if they are dressed by hammering entirely on the beveled side, they will be sure to crack when hardening the second or third time they are dressed, and the tendency to crack will be increased if forged entirely at a low heat, so bear in mind to have a good yellow heat when commencing to forge and finish at a low heat, but forge or hammer equally from both sides.

CHAPTER IX.

The stonemason's nammer—Miners' **tools.**

The Stonemason's Hammer.

A stone hammer is the mason's favorite tool, and which almost every general blacksmith is called upon to dress, but there are very few who understand the process thoroughly so as to give good satisfaction, and knowing that almost every general blacksmith would like to be capable of doing this work successfully, I will give these instructions, and if followed closely the trouble with stone hammers will be over. Have a large fire with the coal well charred (as it is poor policy trying to heat a stone hammer in a small fire); now place the face end of the hammer in the fire and heat slowly to an even yellow heat clear through the hammer for 1½ inches back. Be careful not to heat too fast so that the corners will be at a white heat while the centre is almost black. Uneven heating of this description will cause strains in the steel and have a tendency to crack when hardening.

When dressing a stone hammer always finish at a low dull red heat. After the face end is dressed go over the flat end in the same way, with the exception that the last blows should fall on the flat sides only when at a very low heat. To form the cutting edge on the flat end of a stone hammer it can be forged to shape with the hand hammer or cut to shape with a thin splitting chisel.

Now that both ends are dressed, return the face end to the fire; heat carefully and slowly until the whole face is a cherry red. Never allow the corners to get above a cherry red when heating to harden and should the corners reach the necessary heat to harden before the centre of the face, stop blowing the fire, which will check the heat in the corners and allow the centre to come up to the required heat. To harden, plunge the whole hammer deep into the hardening bath and cool off entirely, at the same time keeping the water agitated so that it will keep cool and act on the hot steel much quicker. Heat and harden the other end in the same way, but be careful not to draw any temper in the end already hardened, which can be overcome by occasionally dipping the hardened end in water while heating the other end, for all ordinary stone hammers never draw any temper.

As almost every blacksmith or tooldresser who has

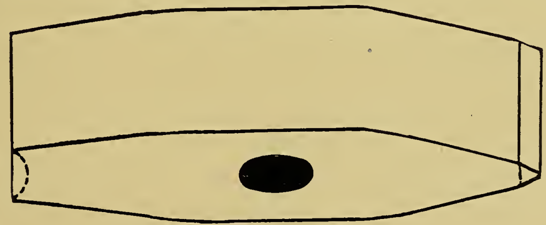


Fig. 82. The stone hammer.

dressed stone hammers has had more or less experience by having them crack, bear this in mind, that it is not the water which causes them to crack, as a great many may suppose, "but instead by the fire," for if a stone hammer becomes overheated in the fire, especially when heating to harden, there will be cracks in it, and if they don't show up the first time after quenching, they will the next, and this information likewise applies to other tools. Sometimes when working on soft stone, some masons prefer a stone hammer made with a hollow face, as indicated by dotted lines in Fig. 82.

Miners' Tools.

As there is a great amount of mining going on throughout the country, first-class sharpeners of miners' tools are in great demand, and likewise receive high wages. The principal tools used by miners are drills, which may be divided into two classes, as, the hand drill and the cross or machine drill.

To make a good fast cutting hand drill, notice the shape of the drill in Fig. 83. I have had drills of this

Fig. 83. Correct shape of miners' hand drill for hard rock.

description drill a hole 19½ inches deep, through hard granite at one sharpening, and for a whole day at a time I have had them average 14 inches to each sharpening, but yet how many drill sharpeners are there that can make a drill average 6 inches in hard granite without resharpening? The real secret of success in order to make a good fast cutting hand drill is this: The drill must be properly hardened but not very far back from the cutting edge, and have plenty of clearance on the corners of the bit. The cutting edge is formed by drawing down to a very short taper, and should be gradually rounding towards the extreme cutting edge (instead of being perfectly straight). As shown in side view of Fig. 83, the cutting edge should also be just a little rounding.

A great many drill sharpeners do not give their drills enough clearance on the corners and at the same time making the drill very rounding in the bit as Fig. 84. Others again make the drills too thick at the

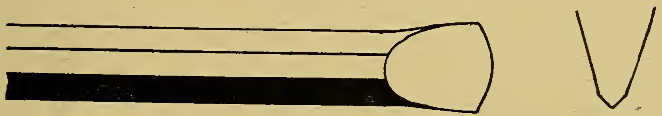


Fig. 84. Incorrect shape of hand drill.

cutting edge, as shown in side view of the same figure. Miners call this shape a bull bit because it will neither cut or break on account of its thickness. This shape of a drill is made by driving back the steel with the hammer when sharpening. Ordinary hand drills for hard rock such as granite, requires no temper to be drawn after hardening.

The Cross or Machine Drill.

The machine drill which does its work by the aid of steam, is entirely different from a hand drill, the bit or cutting edge being in the shape of a cross, as shown in Fig. 85. To make a machine drill, the end is first upset according to the size of the drill to be made, then split in from four sides with a thin hot chisel, afterwards fullering in with square fullers, which will leave the end as Fig. 86. The bevel of the cutting edge is then cut on with a hot chisel.

When forging or dressing the bit of a machine drill, make sure that the centre of the bit is exactly in the centre of the drill, so as not to have one part of the bit longer than another, and have the bit perfectly square and all the cutting edges exactly the same length; also have a good clearance on the corners. Although machine drills are used chiefly in mines they

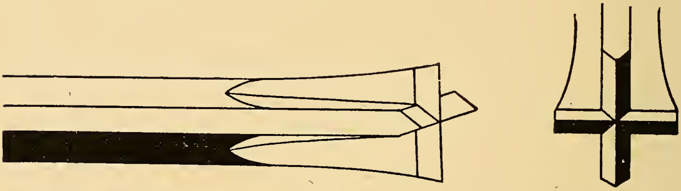


Fig. 85. Illustrating side and end views of a machine or cross drill.

Fig. 86. Showing the shape of a machine drill bit before cutting bevel to form cutting edge.

are also used in stone quarries, but when making a machine drill for soft rock such as limestone, the bit should be made thinner and should also have a longer bevel to form the cutting edge, than á drill which is to drill hard rock.

When hardening a machine drill, heat the whole bit evenly but not exceeding ¾ of an inch back from the cutting edge, then plunge into the hardening bath and cool off entirely. Drills to cut hard rock require no temper drawn, but a machine drill to drill soft rock should be drawn to a dark blue.

The Breaking of Drills when Drilling and the Cause.

The main cause for drills breaking is due to over and uneven heating and also by having too long a heat when hardening, but a great many times the drill will break and although the broken fracture shows a very solid, fine and close grain in the steel representing a piece of glass (a sure sign that the steel was properly hardened), there must be some other cause, and in cases of this kind I used to blame the drill runner for carelessness, when at the same time I was the one to blame for not making the drill the correct shape by not giving the drill enough clearance on the corners.

It should be remembered that if a drill has not enough clearance and binds in the hole it is very easily broken, although it may be properly hardened. Another cause for drills breaking is, when drilling rock that has seams or cracks running through it, but this is a natural cause and cannot as a rule be remedied, although it may be partly overcome when drilling with a hand drill, by making the drill perfectly straight in the bit. When drilling holes 12 or 15 feet deep, the hole is always started with a large drill, but as the hole is drilled deeper the drill will have to be made smaller and longer. A good rule to go by so as to regulate the size of the drill for deep drilling, is to make the bit or cutting edge 1/8 of an inch smaller to every 2 feet in length of the drill. To further explain, supposing a hole is to be drilled 16 feet in depth, the first drill or starter will be 2¼ wide in the bit, while the last one to finish the hole will be 1¼ inches wide in the bit. Generally a gauge is kept on hand for the purpose of regulating the size of the drill, which consists of a piece of thin flat iron having the different sizes cut in it.

The Rock-Cutting Reamer.

Sometimes after drilling, it is found necessary (by the man who does the blasting) to break the rock a certain way, but as satisfactory results cannot be accomplished by the ordinary round drill hole, the hole is cut into an oval shape and in a direction which is most likely to cause the necessary results. This work is known as "reaming the hole."

The reamer is made as a rule from octagon steel, by upsetting according to the size of the drill hole to be reamed, and forged to an oval shape. The long way of the oval cutting face should be a little rounding, while the ends as illustrated, **a a**, Fig. 87, should

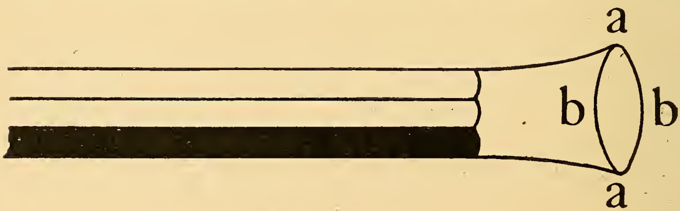


Fig. 87. The rock cutting reamer.

be forged to a sharp point, and the cutting edges, as **b b**, should be perfectly square and sharp. The reamer should be well tapered back from all sides of the cutting face to give a clearance.

To harden, heat the cutting face enough to harden about ¾ of an inch back, then plunge into the bath and cool off "dead cold" and draw no temper. Unless the reamer is to cut soft rock, then draw the temper to a dark blue.

Well Drills.

There is a great amount of well drilling going on throughout the country, consequently the blacksmith is called upon to dress the drills occasionally. The size and shape of the drill depends upon the size of the hole and the hardness of the rock to be drilled. A drill for hard rock is made thick and heavy, and is hardened without drawing any temper. But a drill for soft rock is made thin, and after hardening the temper is drawn to a dark blue. When making wide and thin well drills be careful in heating to forge, but more especially when hardening.

CHAPTER X.

Horseshoers' Tools—How to dress a vise—Sharpening plow shares.

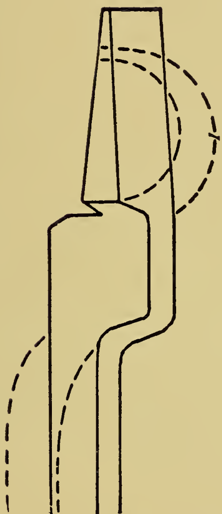
Horseshoers' Tools.

After considering the number of horseshoers there are, it is safe to say that not one in a hundred can make or dress their own tools as they should be done. I have been in a great many horseshoeing shops, where I have seen men working by main strength and energy simply for the want of good tools.

The majority of horseshoers buy their tools in a hardware store, using them until they become dull, then they are thrown away, because the horseshoer does not know how to fix them. But as every horseshoer likes to have good sharp tools, I will give the following instructions on different tools which if put into practice, it will be no longer necessary to work with dull tools.

How to Make and Dress a Pair of Pincers.

To make a pair of pincers, take a piece of ⅞-inch square steel which should be 75 points carbon, forge and bend to shape as illustrated in Fig. 88, leaving the jaw the full width of the steel and tapering towards the cutting edge, but be sure and leave the jaw heavy and strong as indicated by **a** in Figure 88. After the jaw is bent to shape, strike the flat surface of the cutting edge a few good blows by placing the jaw on the narrow or flat end of the anvil. The handles may be



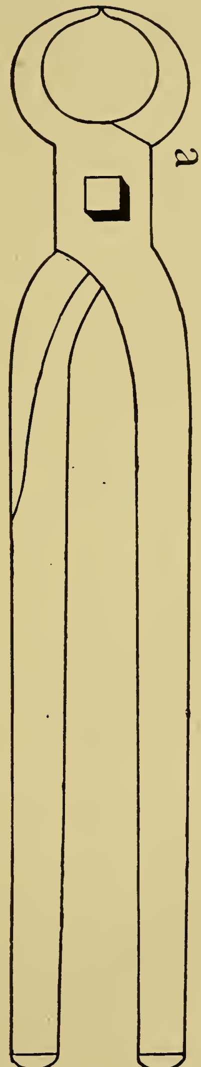


Fig. 88. Illustrating horseshoer's pinchers and how jaw is forged and bent to shape.

drawn out round or half round as suits the man who is to use them, but will be much easier on the hand and be a pleasure to use if the handles are made ⅝-inch half round. After both parts are forged fit together and drill the hole for the bolt or rivet. A steel bolt is preferred to a rivet, as then the pincers can be taken apart very easy whenever necessary.

To harden, heat at least 1 inch back from the cutting edge and draw the temper to a light blue. To dress pincers, hoof cutters or nail nippers, without taking out the rivet, heat the whole jaws to a bright cherry red, then close in or bend to shape. Now have a very low red heat and strike a few blows on the flat surface only of each cutting edge, although it is always best to refine the steel by hammering equally on both flat sides, pincers can be hammered on one side only after being bent to shape, which will be done from the outside. To harden, have the cutting edges close together, so as to heat both at once in the fire about 1 inch back from each cutting edge. Then plunge into the hardening bath and cool off entirely. Now polish the inside of the cutting edges, then draw the temper very slowly and evenly over the fire to a light blue.

Making a Clinch Cutter.

To make a clinch cutter, take a piece of good ordinary tool steel 1 inch wide, ⅜ inch thick and 5 inches long, fuller in as shown in Fig. 89, then draw out the part to form the handhold. Now forge the edge for the clinch cutter, making it a point to finish by hammering on the flat sides of the cutting edge while at a low heat. Draw out the punch almost square, bearing in mind to strike the last two or three blows on the flat side when at a low heat.

Harden the clinch cutter by heating the cutting edge about ⅝ of an inch back, then quench in the bath as indicated by dotted lines in Fig. 90, then polish one side and draw the temper over the fire to a light blue. Harden and temper the punch after the same method as the clinch cutter. Bear in mind that when hardening the

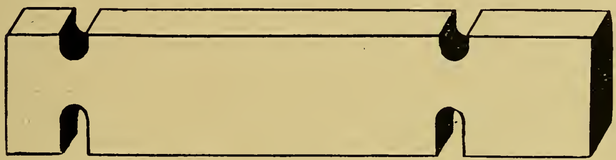


Fig. 89. Illustrating piece of steel fullered in to make a clinch cutter.

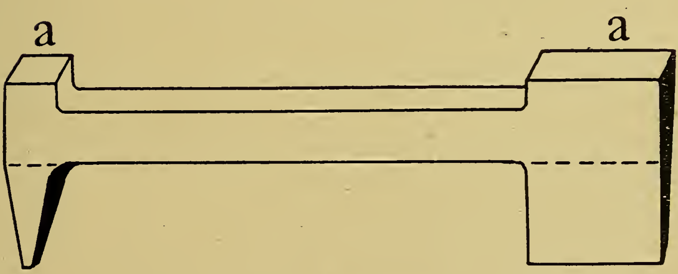


Fig. 90. The clinch cutter completed.

clinch cutter or punch, keep the back as indicated by a a, Fig. 90, perfectly soft, otherwise it will make marks in the face of the hammer. This way of hardening and tempering will apply to all horseshoers' tools. When drawing out a pritchel, always strike the last two or three blows on the flat sides, but not necessarily to harden or temper.

How to Make a Horseshoer's Knife.

To make a horseshoer's knife, follow the instructions as given for making butcher knives mentioned in another chapter, with the exception that the horseshoer's knife must be bent to shape after the hammering is done while at a low red heat, and the temper drawn to a dark blue.

How to Dress a Vise.

It is a common occurrence when entering a blacksmith shop to find the blacksmith doing some work with the vise and at the same time blaming it for not gripping the work firm enough, on account of the teeth being worn smooth in the face and the work turns or slips when in the vise. But if the blacksmith knew how he could repair the vise in a couple of hours' time and make it grip as firm as when the vise was new. In order that the job may be performed successfully and with ease, follow these directions: Take the vise apart and place a jaw in the fire. If the jaw is worn very badly on the corners heat the jaw to a yellow heat and then forge to the proper shape. If the vise is not worn badly, just heat enough to draw the temper. After both jaws are dressed place the vise together to see if the jaws fit, as they should be perfectly level and straight. Now have a very sharp cold chisel and cut in the teeth at an angle across the face, beginning at one corner and going to the other. Then come back cutting at the opposite angle, as Fig. 91. Be careful not to cut the teeth in too deep or too far apart.

To harden, lay the jaw on the fire with the face or teeth side up; heat slowly to a low red heat. Then turn over and heat the whole face to a very even cherry red, but be careful not to overheat the corners and also bear in mind to have the center of the face as hot as is necessary to harden. Then plunge into the hardening bath and cool off entirely. Polish the face bright, and to draw the temper have the surface of the fire perfectly flat without any blaze; lay the jaw of the vise on the fire, teeth side up, and allow the temper to draw very slowly, without blowing the fire, with the exception of just enough to keep the fire from dying out. Allow

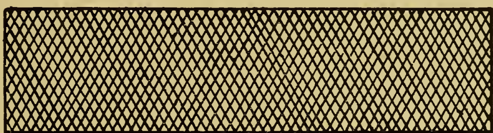


Fig. 91. Showing how teeth should be cut in a vise.

the temper to draw to a dark blue, then cool off, and the vise will hold the work very fast and firm, being equal to any new vise.

If the jaws of the vise are very square the teeth may be cut in cold without heating the vise at all, and which will answer the purpose very well in a temporary way. Make a cold chisel for cutting hard metal (after the directions as are already given in another chapter of this book) and cut in the teeth after the method as illustrated, being careful to keep the cutting edge of the chisel well ground.

Sharpening Plowshares.

There is a great amount of this work done throughout the country, especially in prairie States or Provinces and which in certain seasons of the year forms a great part of the country blacksmith's work, but there are very few blacksmiths who understand this work as it should be understood in order to give the farmer the best results.

The style or shape of the share varies according to the land which is to be plowed, as the land may be so-called stony, sandy or clay land.

The first and foremost point in being able to sharpen a share that will give good results is to have a thorough knowledge of the nature and the working of steel and being without this knowledge is the cause of shares breaking, bending or having so-called water cracks in them.

When sharpening a share have the hammer face very smooth, with the corners a little rounding, so as not to leave any deep marks in the steel, and also have the anvil face smooth, otherwise the share will give trouble by not cleaning when plowing in sticky or clay land, unless the marks are all ground out or the share polished after it is sharpened. When heating so as to draw the cutting edge, always heat the steel to a bright yellow heat, but always be careful not to overheat. When forging the cutting edge, hammer evenly and equally on both sides, but finish from the under side. By doing the last hammering from the under side it will have a very smooth surface on the top side of the share if the anvil is smooth; and always bear in mind to finish hammering when the steel is at a low black red heat, thus refining the steel and making it tough. Do not hammer the steel after it becomes black as hammering steel below a certain heat makes it flaky and brittle and easily broken. (This information will apply to farmers and others who try to sharpen their own shares by hammering them when cold.) Shares to be used in stony land should not be drawn out so thin as those which are used in sandy or land that is free from stones.

To harden a plowshare, heat the extreme cutting edge to a low cherry red (or just enough to harden) the full length of the share by moving back and forth through the fire, then plunge into clean cold water point first and in a vertical position. A plowshare sharpened and hardened after these directions will give unlimited satisfaction. But although the instructions given in hardening will prove most successful when it can be accomplished, there are times when a share cannot be hardened the whole length of the cutting edge in the blacksmith's fire. This will apply to very large and long shares, so when hardening very long shares do not try to harden the whole cutting edge, but harden only the point of the share from **a** to **b**, as illustrated in Fig. 92, a long share hardened

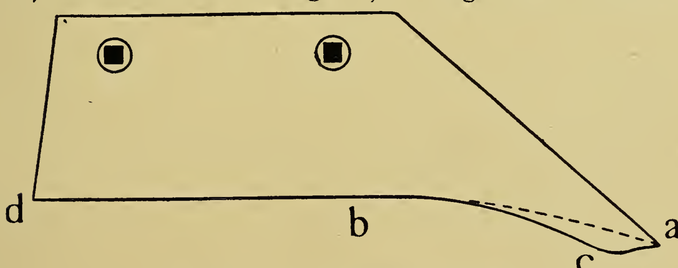


Fig. 92. An ordinary plowshare.

after these directions will give good results if the whole cutting edge has been forged and hammered after the instructions formerly mentioned.

When sharpening plowshares in order that they will give good results and cause the plow to run level, make the point a little rounding, as marked **c**, Fig. 92, otherwise if made square it would gather up long grass and cause the plow to run out of the ground. Also have the cutting edge in a straight line from the wing **d** to the point **a**, so that if placed on a level floor the cutting edge would come in contact and rest evenly on the floor, the entire length of the share. Plowshares for breaking plows are made with a very sharp point as illustrated by dotted lines in figure.

How to Make Square Holes in Plowshares.

A great many blacksmiths when making plowshares have more or less trouble to make proper shaped holes, in order that the bolthead will fit properly and not turn around when the share is being tightened up firmly to the plow head. To do this work correctly after the hole is drilled and countersunk, and the hole is to be made for a square cornered plow bolt, make a square drift or punch as Fig. 93, having it just

Fig. 93. Punch for squaring holes in plowshares.

a trifle larger than the square of the bolt head, also have the cutting face perfectly square and flat, it should be a little smaller back of the cutting face to give clearance. Harden the punch and draw the temper to a blue.

To make the hole square, place the share on the anvil holding it firm, then punch the hole as already drilled, from the opposite side of the countersink. By following this method and holding the punch directly and evenly over the hole, the corners will be cut out leaving the hole very square and neat.

CHAPTER XI.

How to make a harnessmaker's knife—Butchers' tools—Railroad tools.

How to Make a Harnessmaker's Knife.

To make a harnessmaker's knife will try the skill of the expert to its full extent, leaving aside an amateur steelworker, but if the amateur will follow the directions very closely he will meet with the best of success. To make one, use sheet cutlery steel of 75 points carbon and 3-32 of an inch thick, but the size of the steel to be used will depend on the size of the knife to be made. The size of the knife depends a great deal who is going to use it, as some knives are made as wide as 6 inches, while others do not exceed 4 inches, and in a great many cases smaller. After getting steel the proper width, draw an outline of the knife on the steel according to the size of the knife to be made, but bear in mind not to cut the full size of the knife as the cutting edge is yet to be drawn out, but cut out 3-16 smaller, as indicated by dotted line a, a, a, Fig. 94. If the steel is not long or wide enough to cut the full length of the shank, it may be cut as indicated by dotted line at b and then drawn out to shape, and in extreme scarcity of steel, the shank may be welded on at c, but this is a difficult job owing to the steel being so wide and thin, but it can be done with care.

After being cut to shape from the steel and the shank formed, forge the cutting edge of the knife by taking a deep cherry red heat, and commencing to hammer at the point marked **f**, hammering equally from both sides until all the cutting edge is drawn out,

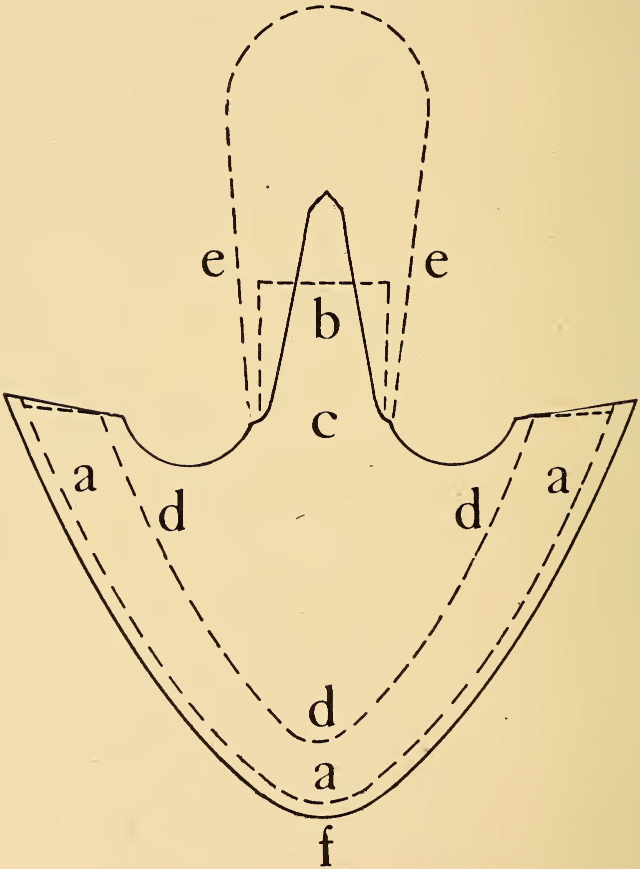


Fig. 94. The harnessmaker's knife.

although it may be necessary to take two or three heats before all the cutting edge is drawn out.

Now to refine and pack the steel, get the knife to a very dim red, then hammer evenly on both flat sides of the whole cutting edge; now heat again to a very low heat and then hammer, but this time do not hammer directly on the cutting edge, but instead go back from the extreme cutting edge ¾ of an inch, as indicated by **d**, **d**, **d**, which will take the strain out of the steel. Now anneal the knife by heating to an even blood red heat all over the knife (except the shank), then pack in lime or ashes, allowing it to remain there until perfectly cold, which will also help to take the strain out of the steel, afterwards filing the edges smooth. To harden, heat the knife to a low cherry red one inch back from the cutting edge in the blaze of the fire, at the same time moving the knife in a circular motion in order to heat the whole cutting edge very evenly (and be careful to avoid heating the cutting edge in streaks), then plunge the whole knife in the hardening bath from a vertical position, and cool off. If the cutting edge was forged and hammered very evenly and hardened evenly, the knife will come from the hardening bath perfectly straight, but otherwise there will be a crook in it, however polish one side of the knife as far back as it is hardened, and draw the temper very slowly over the fire, moving the knife in a circular motion back and forth to insure a very even temper, draw the temper to a dark blue (which will apply to all leather cutting tools), but before cooling off, should there be a crook in the knife, take it out by straightening it on the anvil with the hammer, then cool off and the knife is finished. Should it be impossible to take out all the crook with the hammer after the temper is drawn, a certain amount can be taken out and the knife made perfectly straight when grinding, but if the knife crooks a great deal when hardening, yet not enough to crack the steel, it will have to be heated again, straightened and annealed. However, if these directions are followed closely, there will be no danger of the knife crooking of any account, and the knife will hold a very keen edge on the hardest of leather. The dotted lines at **e**, **e**, **e**, represents an outline of the handle. To enable the shank to stay firm in the handle it should be feathered with a very sharp cold chisel, as illustrated.

How to Make a Butcher's Steel.

Butcher's steels are principally made by machinery, as the knowledge for making a good butcher's steel by hand is unknown by most of the blacksmiths or toolmakers, although a steel properly forged and hardened by hand will outwear any that can be purchased in a hardware store. To make one, take a piece of round tool steel say ⅝-inch diameter, after fullering in at **a**, Fig. 95, to form the shank and also fullering a

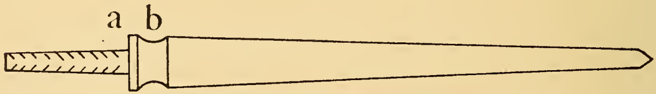


Fig. 95. The butcher's steel.

little at **b**, forge the steel tapering and very round. To put in the teeth, make the steel firm by putting the shank in a vise, now have a coarse sharp file, place it square across the steel, press hard and draw lengthwise of the steel from end to end and equally all around, two files will be found more convenient than one, on account that the teeth can be put in two sides of the steel at once, which is done by holding the ends of the files in the hands with the steel between the files.

Forge the shank long and square and feather it (as illustrated in Figure 95), so that it will stay firm in the handle. To harden, see instructions for hardening tools with fine projections.

Hardening Tools With Fine Projections.

To harden tools of this description, I will select a butcher's steel, as the teeth are very fine. Should this tool be heated to harden in the open fire as other tools, the teeth will lose their fine cutting edges and which is especially required on a steel in order to sharpen knives. To overcome this difficulty use the following compound: Take equal parts of wheat flour and salt, also a little water, then mix together to the consistency of soft mud. Have the steel perfectly dry and clean, then roll it in the compound covering the teeth of the steel well from end to end, then heat to a good cherry red the whole length of the tool (excepting the shank), then plunge vertically in the hardening bath, allowing it to remain there until perfectly cold, then clean off, but draw no temper, as the steel will not be too hard. Very fine files may also be hardened after this method and all other similar tools.

The Butcher's Cleaver.

A butcher's cleaver is made from flat steel ¼ inch in thickness, but the width of the steel will be according to the size of the cleaver to be made. When forging a cleaver, as Fig. 96, weld on an iron shank to the shape, as illustrated, so that it will be strong. The cutting edge of the cleaver is forged by drawing down the steel to a very short bevel equally from both sides while the steel is at a good yellow heat, then finish by hammering at a low heat on the beveled edges and backwards a short distance on the main body of the tool. To harden, heat the whole cutting edge backwards about ¾ of an inch to a cherry red by moving back and forth through the fire so as to heat evenly; then quench, afterwards drawing the temper to a light blue by moving it back and forth over the fire.

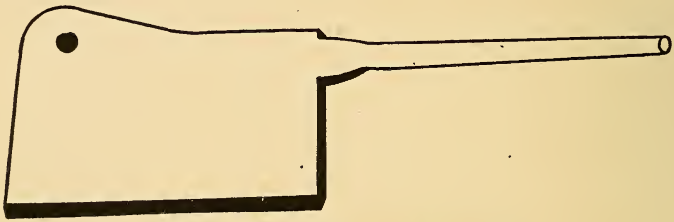


Fig. 96. The butcher's cleaver.

Butcher knives will be found fully explained and illustrated in another chapter of this book.

How to Dress a Railroad Pinch Bar.

Wherever railroad cars are to be moved by hand, it is often found necessary to take the pinch bar (as this is the tool principally used for this work) to the blacksmith to have it dressed or sharpened, but this work is very little understood by the average blacksmith and so the tool fails to give good results, it being too soft or otherwise the heel will break off.

To dress, heat the whole end of the pinch bar to a good yellow heat but not necessarily very far back, and then dress to the shape of Fig. 97. To harden, heat the face of the tool from heel to point to about 1 inch back to a very even cherry red, being careful not to get the heel overheated, then dip in the hardening bath to 1½ inches back at an angle as indicated by dotted line in figure. Now polish the heel and side bright and draw the temper, by placing the part between **a** and **b** directly over the fire, heat slowly and draw the point to a blue temper, but keep the heel as indicated by **c** cooled off by occasionally dipping it in water to the depth, as illustrated by dotted line (as the heel cannot be too hard when properly hardened) while drawing the temper at the point, then cool off

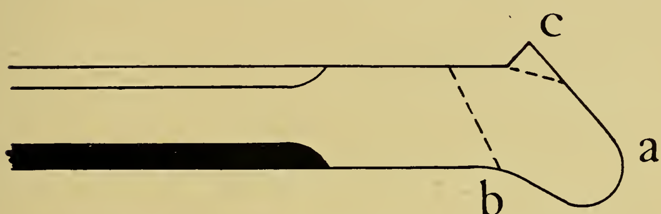


Fig. 97. Correct shape of punch bar.

and you have dressed a pinch bar that will give unlimited satisfaction.

There are different kinds or shapes of pinch bars, but the one as illustrated in Fig. 97 has been found by practical experience to be the best, as it is very strong. The one illustrated in Fig. 98 is perhaps more commonly made and used, but the fault of this pinch bar is, it is not heavy or strong enough at the point, consequently when moving heavy or loaded cars the point is very apt to bend or break. When hardening a pinch bar, as Fig. 98, harden the heel only, as the point will break if hardened or tempered. If at any time it is necessary to put a new heel on a pinch bar, upset the steel to the shape of Fig. 99, then forge to shape. The illustration as Fig. 99 will also apply when making new pinch bars.

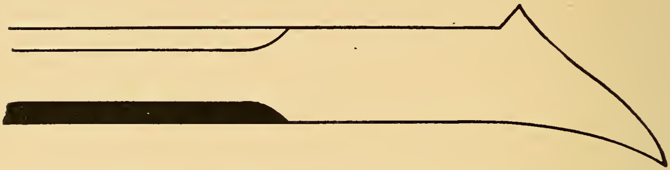


Fig. 98. The ordinary shape of pinch bar.

Fig. 99. Showing steel upset to forge heel on punch bar.

The Spike Maul.

When building or repairing railroads, the spike maul or spike hammer is greatly used, its principal use being to drive spikes in the ties. To make one, take a piece of 2-inch square steel and after punching the eye forge to the shape as illustrated in Fig. 100, as will be

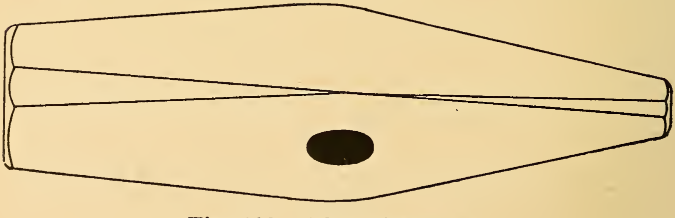


Fig. 100. The spike maul.

seen one end is drawn down very small to about ¾ of an inch across the face, both ends are dressed as an ordinary hammer. To harden, heat the large end of the spike maul first to a cherry red about ¾ of an inch back from the face, having the center of the face at an even heat with the outside or corners in order that it will harden properly, then dip in the hardening bath to about 1½ inches deep. Then polish the face and allow the temper to run down to a light blue. If there is not enough heat in the spike maul to drive down the temper it can be drawn by holding the end over the fire, and slowly and continually turning it around until the temper is drawn to the desired color. Harden and temper both ends the same way, but be careful not to draw the temper in the end which is already hardened and tempered while heating to harden the second end. However, if the large end is hardened and tempered first, there will be no danger of the temper drawing in the other end, as the small end can be heated so much quicker and so the heat has not time to run to the large end enough to draw the temper, but in cases where there is danger of the temper drawing, cool off the tempered end in water. A spike maul is not so apt to get hollowing in the center of the face as an ordinary hammer, but, instead, is more apt to break off at the corners, so when dressing make the corners rounding, but not too much.

The Claw Bar.

In railroad construction, the claw bar is very extensively used, its principal use being to pull spikes. Dressing claw bars when badly broken is somewhat of a difficult task and requires skill to forge them to the proper shape. To dress a claw bar, as shown in Fig. 101, when badly worn or broken, heat to a deep yellow heat, then forge to shape, as illustrated by side view in figure, then close the claws, as **a**, **a**, front view in figure, to within ⅜ of an inch apart at the extreme ends. Now have a fuller as Fig. 103, which should be

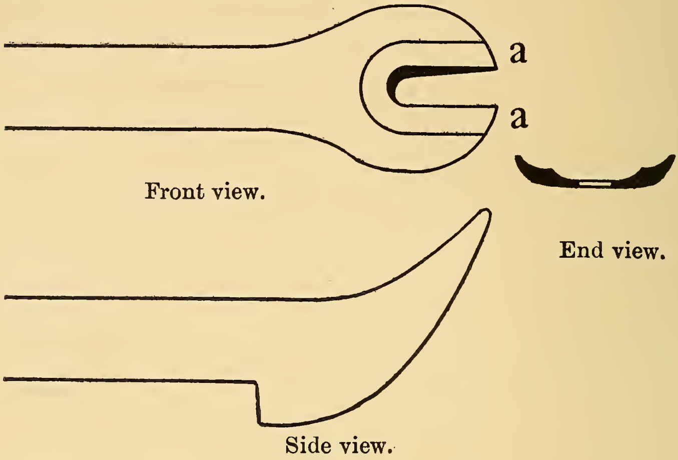


Fig. 101. Illustrating claw bar.

⅛ wider than the body of a railroad spike, and drive the fuller down between the claws. This will straighten the claws and bring them the right width apart. Now

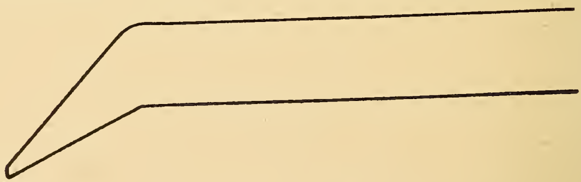


Fig. 102. Side view of opposite end of claw bar.

have a small gouge and gouge out the claws from the front side, the extreme ends should be very thin (as shown in end view of figure, in order to go under the head of a spike when pulling it), but should gradually become thicker back from the extreme ends.

Claw bars must not be hardened or tempered, or they will break very easily when pulling a hard spike. The opposite end of a claw bar is generally made with a

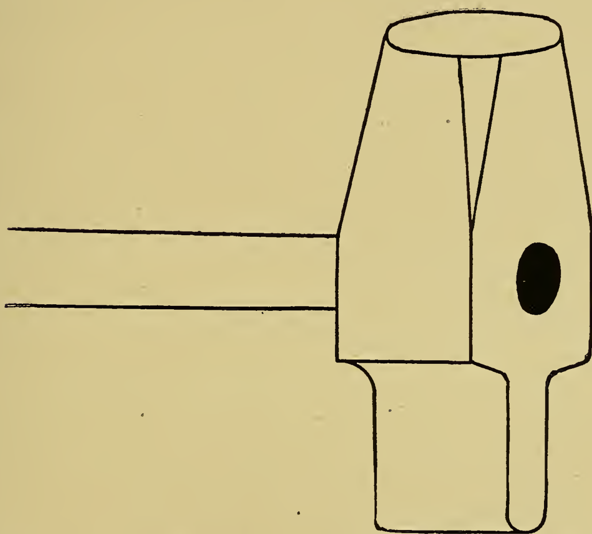


Fig. 103. Illustrating kind of fuller used, when dressing claw bars.

bent chisel point as Fig. 102, which is used sometimes to loosen the spikes before pulling. There are also many different shapes of claw bars, but the one illustrated is the principal one used, and they are all dressed after the same method or principle.

CHAPTER XII.

Miscellaneous tools—Case hardening.

The Bricklayer's Set.

A bricklayer's set has a very wide cutting edge, while the shank or handle is ¾ octagon or square, to make one, take a wide piece of flat steel fuller in, then draw out the handle, after which the cutting edge is forged. But in case a piece of steel, as just mentioned, cannot be had, the only way to forge the cutting edge (which should be about 3 inches wide) is by

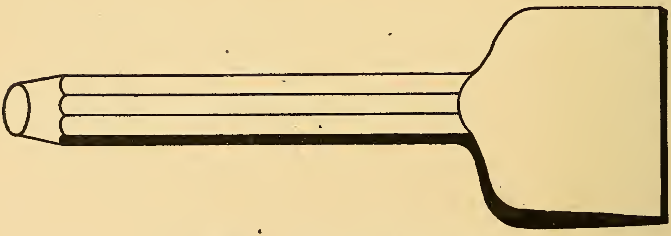


Fig. 104. The bricklayer's set.

upsetting a piece of octagon or square steel as the case may be, then flatten out until wide enough. To put on the cutting edge file only from one side, the other side being left perfectly square and flat.

Harden as any similar flat tool and draw the temper to a dark blue. All tools for cutting brick should be tempered to a light blue.

How to Harden and Temper Wire Nippers or Pliers.

Heat the jaws back a little past the cutting blades, as indicated by dotted line **a**, Fig. 105, to a very even cherry red, then dip into the hardening bath to dotted line **b** above the rivet. Now polish the upper side

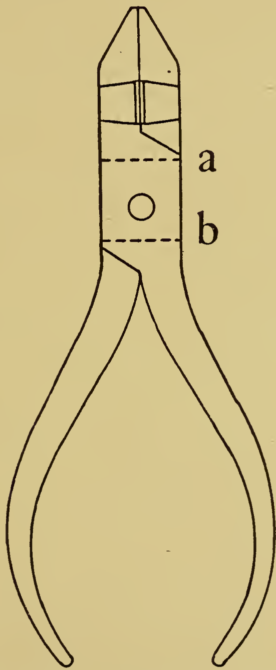


Fig. 105. The wire nippers.

bright and draw the temper over the fire very slowly and evenly to a light blue, making sure that the cutting edges or teeth are properly tempered. These instructions will apply to all similar tools.

How to Make a Razor.

To make an ordinary razor use steel 3-16 by 7-16 of about 75 points carbon. After the shank is fullered in a little for the finger hold, then forged to shape, the blade is formed into shape by bending the steel a little edgewise, afterwards being forged, hammered and hardened, as is explained in making butcher knives

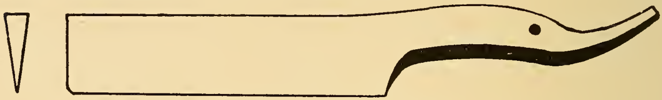


Fig. 106. The razor.

(which will be found in another chapter of this book), draw the temper to a purple. A razor is hollow ground after being tempered and which should be done by an expert, if a razor is made after these instructions and the hollow grinding done without drawing the temper, it will hold a very keen edge, which will equal any razor manufactured. End view, Fig. 106, illustrates shape of razor blade before being hollow ground.

To Make a Scraper.

A scraper for taking off paint, grease, etc., off boiler plate or any other material and leave a bright smooth surface, is chiefly made from octagon steel, the size of steel used according to the width of scraper required, although for an ordinary scraper ⅝ octagon will do. To make one, forge the steel perfectly flat ⅛ thick and about 3 inches in length and 1 inch wide. The end of the tool is left perfectly square, the scraping or cutting edges being the corners, which are ground very sharp.

To harden, heat to about 1 inch back from the scraping edges, then quench in the hardening bath and cool off the whole tool entirely. Draw no temper as the tool is required to be very hard; it will give excellent results if properly forged, hammered and hardened.

Fig. 107. Showing scraper for boiler plate, cast iron, etc.

Hardening Jaw of Pipe Vise.

To harden a jaw of a pipe vise, heat all the teeth to a very even cherry red or just enough to harden, then quench the whole tool edgewise from a vertical position in the hardening bath and cool off entirely. Polish one side bright and draw the temper to a dark blue by placing the jaw on a heated iron plate which should be a little wider than the jaw, in order that the jaw may be tempered evenly. These instructions will apply to all tools for holding pipes, clamps for holding bolts and all similar tools.

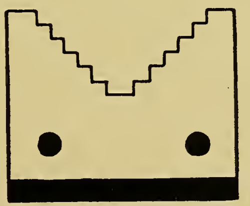


Fig. 108. Jaw for pipe vise.

Hardening and Tempering Blacksmiths' Bolt Clippers.

A good set of bolt clippers is a tool prized very much by the general blacksmith, and yet very few blacksmiths are capable of repairing them properly when they get out of order, the greatest trouble lying in the hardening and tempering.

After the clippers are dressed and the cutting edges made to fit properly and closely together, heat the whole cutting edge to a very even cherry red, then quench in the hardening bath from an upright position to about one inch from the cutting edge. Polish the cutting edge bright and draw the temper slowly and evenly over the fire to a light blue. These directions for hardening and tempering bolt clippers apply to the kind that are used principally nowadays, which have a long shaped blade and by dipping into the hardening bath (after the fashion of hardening a cold chisel) one inch back from the cutting edge, will enable the temper to be drawn more accurate and evenly with no danger of the temper running out at any part of the cutting edge if the least care is exercised when drawing the temper over the fire. However, some bolt clippers are made with a short blade which is held in place by a set screw or some other contrivance, the knife or blade not exceeding one inch in length. In a case of this kind heat the whole blade to a very even cherry red, then quench the whole tool in the hardening bath and cool off entirely, afterwards drawing the temper on a piece of hot iron or by holding it over the fire.

Bolt clippers are made exclusively for cutting iron bolts or rivets and must not be used to cut cast steel, if used on cast steel the clippers will lose their sharp cutting edges or will break.

Tools for Punching or Gumming Cross Cut Saws.

A punch and die for gumming cross cut saws are made a great deal after the same principle as a punch and die for punching teeth in stone cutters' chisels, with the exception that the saw tools are not beveled off, but instead are left perfectly flat, the hardening and tempering being the same. See "punching teeth in stone cutters' tools" in another chapter of this book. All punches for saw sets, after hardening, should be tempered to a light blue.

The Scratchawl.

A scratchawl for scratching or marking cast iron, boiler plate, etc., is as a rule made from small round steel, the point being drawn out very long and thin. To harden, heat to about ½ inch back from the point, but owing to the fineness of the tool be very careful not to overheat the extreme point, then quench and cool off entirely, draw no temper, as the point is required to be very hard. Most mechanics who have use for a scratchawl prefer the opposite end flattened and bent to shape as Fig. 109.

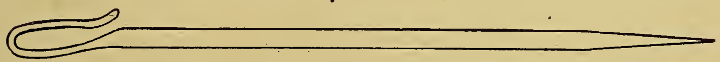


Fig. 109. The scratchawl.

Hardening and Tempering Circular Blades of Pipe Cutter.

To harden circular blades of pipe cutter, heat the whole blade to a very even cherry red heat, then quench the whole tool and cool off entirely. Afterwards draw the temper to a dark blue on a piece of heated flat iron. Should there be a great many of these tools to be hardened at once and there is no heating furnace in the shop, place a piece of flat iron on the surface of the fire, heat it to a deep red heat, then place the blades on it, as the blades are of a flat shape it will not take long for them to heat hot enough to harden. Place 5 or 6 of the blades on the heated plate at one time, but watch carefully and keep turning them over for fear some of them should become a little overheated or heated in streaks. After quenching draw the temper also on a hot iron.

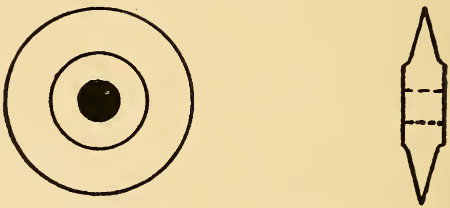


Fig. 110. Flat and end views of circular blade for pipe cutter.

Heating a Tool According to Its Shape.

When heating, to harden tools of an irregular shape as an eccentric ring, Fig. 111, the heavy or thick side

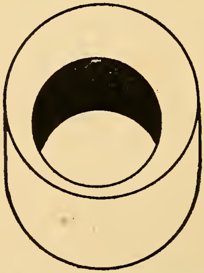


Fig. 111. An eccentric ring.

should be heated first, then allow the thin part to come up to the heat gradually so as to avoid unequal contraction when hardening. When quenching plunge the heaviest part of the tool into the water first.

Making, Hardening and Tempering an Alligator Pipe Wrench.

To make an alligator pipe wrench, take a piece of flat steel the size according to the size of wrench to be made, heat and then fuller in as **a**, **a**, Fig. 112, afterwards drawing out the handle **b**, now cut off the four corners, as illustrated **c**, to shape as indicated by dotted lines with a thin splitting chisel which will give the shape of the wrench. Now punch a small hole in the wrench at **d** and cut out the part **e** as dotted lines. If the wrench is made where there is a machine shop the teeth can be put in with a planer, but if made in an ordinary blacksmith shop the teeth will have to be filed in. The teeth can be put in one or both jaws, as may be desired. Fig. 113 shows the completed wrench with teeth in one jaw.

To harden, heat the jaw (having the teeth) enough to harden to dotted line **a**, Fig. 113, then quench into the hardening bath to dotted line **b**, polish one side bright and draw the temper over the fire to a dark blue. Should both jaws of the wrench have teeth it can be hardened and tempered after the same method, but if the wrench has teeth in only one jaw, it is not necessary to harden or temper the jaw having no teeth. These directions will apply to all kinds of alligator wrenches or similar tools.

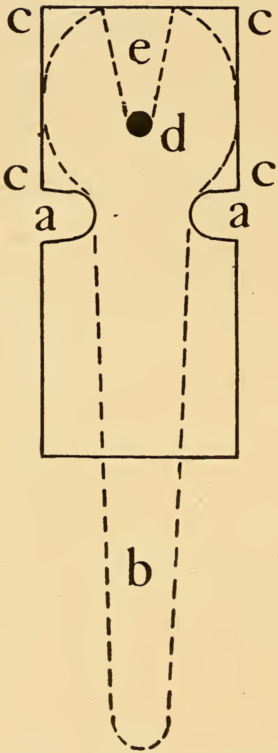


Fig. 112. Showing how alligator pipe wrench is made.

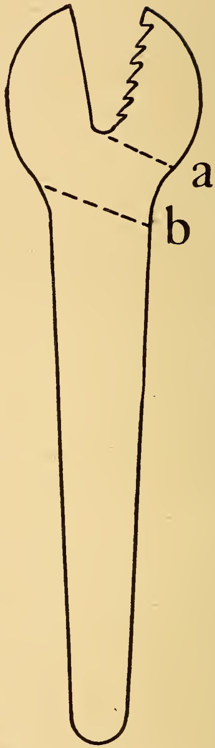


Fig. 113. The completed wrench.

Hardening and Tempering Pruning Shear Blades.

If the blade is short, heat the whole blade to an even cherry red heat, then quench in the hardening bath about an inch back from the cutting edge and in an upright position, afterwards polish and draw the temper over the fire to a light blue. Should the blade be long, say 6 inches or more, harden and temper as a butcher knife, mentioned elsewhere in this book.

The Center Punch.

A center punch for marking or centering holes that have to be drilled in iron, steel, etc., are drawn down to a very sharp point as shown in Fig. 114. After hardening, allow the temper to draw to a dark blue,

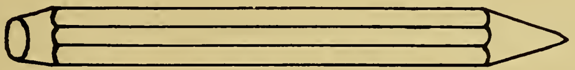


Fig. 114. The center punch.

which will do for punching all ordinary material, but for punching very hard metal the temper must be regulated accordingly. See instructions as is given in tempering a cold chisel in another chapter of this book.

The Nail Set.

A nail set for driving nails deep into the wood is generally made from 3/8 octagon or square steel. The end

Fig. 115. The nail set.

for striking upon the nail is tapered to 1/8 at the point. Harden not less than 3/4 of an inch back from the point and draw the temper to a light blue.

Hardening and Tempering Steel Stamps.

Stamps for lettering or marking cold iron, steel, etc., are hardened as any ordinary tool by being heated and quenched about one inch from the stamping end, and afterwards drawing the temper to a purple. Stamps for marking hot iron or steel will be best tempered to a light blue. When stamping cold material, be sure to always have the stamp perfectly level and firm on the material to be stamped, otherwise the tool will be apt to break.

Making a Gouge.

To make a gouge for cutting hot iron or steel, it must be first made as an ordinary hot or splitting chisel, but the cutting edge should be left a little wider than the body of the chisel, then it is placed over a bottom swage and while at a cherry red heat take a fuller and place it exactly in the center of the chisel and directly over the center of the swage, then strike the fuller a good blow or two with the sledge, which will set or force the chisel down into the swage and form the gouge. Bear in mind that a certain size of swage and fuller must be used according to the size of gouge to be made, for example, and to have the best success, supposing a gouge is to be made to cut a circle of one inch, the swage must be one inch and the fuller ⅝ of an inch in size. This method will also apply to making a carpenter's gouge. A gouge for cutting cold iron or steel must be left thicker than one made to cut hot material and which will require a smaller size of fuller when making one. Also bear in mind to have the steel at an even cherry red heat (but no hotter) when bending a gouge to shape, otherwise should it be bent while at a white or high yellow heat, the hammering which is done at a low heat (before bending) is all taken out and it will never hold a keen cutting edge or otherwise if the gouge should be bent at a very low or black red heat there will be strains put in the steel which will cause the gouge to crack while hardening.

To harden a gouge, follow the directions given in hardening and tempering a blacksmith's hot or carpenter's chisel, which will be found fully illustrated in other chapters of this book.

Hardening and Tempering Carpenters' Augers That Have Come Through a Fire.

Although augers are made, hardened and tempered entirely in tool factories, there is often a case when an auger has simply lost its temper and become soft in a fire by the burning of hardware stores, etc., although otherwise the auger is not damaged in the least and which can be made as good as new (unless already overheated) by the following method: Heat the auger very carefully in the blaze of the fire, making sure that the cutting edges and point are heated very evenly to a cherry red, then quench into the hardening bath about one inch back from the cutting edges, polish bright and draw the temper very carefully over the fire (having no blaze) to a dark blue. These instructions will apply to all augers, brace bits and all similar tools for boring wood.

Case Hardening.

Case hardening is a process that iron or soft machinery steel is put through so that the outside will be made very hard, while the centre still remains in its soft state. Case hardening is a very useful treatment, as certain parts of machinery are to be very hard in order to stand the wear, and iron or soft machinery steel can be made to give very satisfactory results when case hardened properly. For a great number of purposes machinery steel tools will take the place of tools made from cast steel, and is less expensive as the stock is cheaper and the tools are much more easily made and will last just as long when properly treated.

When case hardening parts or ends of tools, such as set screws, the process is this: Heat the end of the set screw to be hardened to a bright cherry red, then roll the heated end into powdered prussiate of potash and return to the fire and heat to a bright cherry red, then plunge into cold water and cool off entirely, when it will come out of the water presenting a white appearance and will be found to be very hard if tested with a file. This method will apply to all small tools that are to be case hardened all over, but not to a great depth.

When case hardening a great many tools at once where the whole surface is to be case hardened and to a great depth, pack in an iron box with any case hardening compound, such as granulated or charred bone, charred leather, charcoal and potash. But in packing the pieces or tools in the box be sure that they do not come in contact with the surface of the box or with each other, but keep at least ½ inch apart by packing the case hardening compound between. The box should be made air tight, and then placed in a furnace or heating oven which must be left there long enough according to the depth that the contents are to be case hardened. If the furnace is kept at a bright cherry red heat, the contents of the box will be case hardened to the depth and rate of 1-16 of an inch per hour. Afterwards the contents are taken from the box and quenched immediately in cold water and cooled off entirely. When quenching pieces or tools to be case hardened, the process is the same as cast steel, for example, take a flat piece of iron or soft steel 6 inches square by 1 inch thick it must be quenched by plunging into the water edgewise and from an upright position, also long slender pieces (for explanation 1 inch square and 6 inches long) must be quenched from a perfectly upright position and never at an angle, otherwise if the pieces are quenched at an angle they will be apt to warp.

CHAPTER XIII.

General information, pointers and ideas in reference to steel-work and toolmaking—Conclusion.

The Correct Meaning of a Cherry Red Heat.

We often hear blacksmiths and other mechanics when in conversation about steel saying such a tool or piece of steel should be heated to a cherry red to harden or temper, but although their advice may be quite true how many are there who know the correct heat and meaning of a cherry red heat? If every blacksmith and other mechanics who claim to know all about steel were judged according to the class of tools they make, then I am afraid there would be a great many who do not understand the correct heat or meaning of a cherry red heat. I personally know some blacksmiths and tooldressers who will tell me they know a great deal about steel and its nature, who, when they are hardening a piece of steel will often heat the steel to a bright yellow heat when they think it is a cherry red, while others again will not have the steel heated above a dull red heat, consequently the steel is heated too much or not enough to harden. But for the benefit of those who wish to know and are anxious to learn the real meaning of a cherry red heat, I will explain. A cherry red heat is the lowest heat at which a piece of steel containing 75 points carbon will harden successfully. But when hardening a piece of steel containing 100 points or 1 per cent of carbon a lower heat than a cherry red will do to harden it, and it should always be well remembered that the lowest possible heat that any steel will be sure to harden at, so much better will be the results when the finished tool is put into use, consequently the steel (to have the best results) must be heated to harden according to the carbon it contains.

Heating to Harden According to the Size of the Tool.

When heating to harden large or heavy tools, it should be remembered the heat should be a shade higher than that used to harden small or thin tools as the water will act much quicker on a thin piece of steel than a thick piece. Thick heavy tools will cause a great amount of steam, which has a great tendency to hold the water back from the steel, and to more fully explain, if two pieces of steel are taken to be hardened, the larger piece being 3 inches square, the smaller being ½ of an inch square, but both pieces containing the same amount of carbon. Now if the smaller piece is heated to the lowest possible heat, that it will harden at successfully clear through the piece. Then heat the larger piece to exactly the same degree of heat, and it will be found after hardening upon close examination that only the corners are hardened.

When quenching the ends of large tools or wholly, keep the water well agitated and so help to keep the water cooler next to the steel. If it is possible to have an overflow pipe attached to the hardening bath and another one to flow in at the same time, it will give good results when hardening large pieces as the hot water will continually flow away from the steel.

Charcoal for Heating Steel.

A saying that I have heard a great many times is, always use charcoal to heat steel, while another saying is, steel is tougher when heated in charcoal. It has been found out by practical and scientific experience that sulphur is one of the greatest enemies to be avoided when heating steel, and while charcoal is free from sulphur it is the only advantage connected with charcoal to heat steel by. But as to toughen steel by heating it in charcoal, is a saying entirely without foundation, as there is nothing that will toughen steel except by hammering it at a certain heat and hardening it at the proper heat.

In reference to heating steel by the use of charcoal, it does not matter what kind of fuel is used so long as it is free from sulphur and the necessary heat can be obtained, whether it be charcoal, coke, coal, bark or corn-cobs. Now, reader, never adopt any old saying or process unless you have found out by experiment or trial that it is true. Some mechanics are too ready to pick up quack theories by having heard some one say so, and consequently when the advice is put into practice the result is failure. Reader, there are too many mechanics who belong to this class, you must belong to the class who do their own thinking, which is the sure road to success. Again, never turn a deaf ear to any one who has a suggestion to make, no matter who the man is or what kind of clothes he wears, the author has picked up some very valuable information in this way from some of the most illiterate men who only excelled in one point and which has been found out by experiment to be reliable.

The Scaling of Steel After Hardening.

The scaling of steel after hardening, as a rule, is never observed by the average steelworker, but to the expert it means a great deal. By the way the steel scales off a good steelworker is enabled to tell good or poor steel, also hard or soft steel, hard steel containing 100 points carbon if heated to a cherry red will scale off clean, leaving a white surface, while a piece of medium carbon steel of 75 points of good quality and heated to a cherry red will scale off in spots leaving a speckled black and white surface, but the scales left on will be very thin and light. But if a piece of steel of medium carbon and of poor quality be hardened, the scales left on will be of a thick and heavy nature, and steel very low in carbon and of poor quality will not scale off at all unless heated to a bright cherry red (almost yellow). This class of steel is worthless for making good tools. The temper of a tool may also be regulated by the way the steel scales off. For illustration, if a cold chisel (for ordinary work) after hardening should be partly scaled off, the temper should be drawn to an ordinary light blue, but should it scale off perfectly clean and white allow the temper to draw to a very light blue, bordering on a grey.

Sometimes when heating steel in a coke or smoky fire the steel will scale off as already mentioned, but instead of leaving a white surface it will present a very dark surface and unless observed closely it will be hard to tell whether the steel has scaled off or not. The scaling of steel, however, is only in reference to tools that are hardened after being finished at the anvil, as tools that are ground bright on a grindstone or otherwise machined will not scale off.

By the scaling of steel a good steelworker can tell if the tool has been overheated when hardening, as the surface of overheated steel will show a very bright white color, the best way, however, to learn the difference as regards the scaling off of a piece of overheated steel and of steel that was hardened at the proper heat, take two pieces of steel from the same bar of good quality and medium carbon, then heat one to a cherry red and the other to a deep yellow or white.

Quality and Quantity.

If tools can be made or repaired very quickly and in great quantities by a toolsmith or any mechanic, producing at the same time excellent quality, it will be a great saving of time, but there are very few who have such good ability. But to the ordinary toolsmith or steelworker I wish to give this advice, "Let quality at all times be preferred to quantity," and always see how well you can make a tool before seeing how fast you can make it, speed will naturally come but quality must be practiced in the beginning. For illustration, we will take two different toolsmiths who are making cold chisels, one may be able to make in his own way 50 chisels while the other man is only making 25, but the one who makes 25 is having a much easier time and is always up to his work, although he has as many mechanics to keep at work as the man who makes 50, but how is that the reader asks; it is because he prefers quality first. The other man is working as hard as he can, he never catches up to his work because he prefers quantity first. The slow man in action but not in workmanship makes one chisel that does as much work as three chisels made by the swift man, consequently every chisel made by one toolsmith does its work while almost every chisel made by the other toolsmith is continually breaking, bending or being too soft.

Quick Methods of Working.

When making or dressing a great many tools of the same shape and used for the same purpose, first of all consider the quality, then consider quantity and the quickest way of doing the work. For example, supposing 25 cold chisels are brought at one time to the toolsmith to be dressed, do not dress, harden and temper them one by one, but instead dress or draw out all the chisels (using two pair of tongs and so keeping one chisel heating in the fire while the other one is being drawn out) before hardening and tempering them.

When hardening the chisels have the surface of the fire flat, then lay about 4 of the chisels on top of the fire and heat very slowly, as they become hot enough to harden quench deep into the hardening bath. After polishing lay the chisel down on the forge or in some very convenient place near the fire (so that the toolsmith may be able to watch the chisels that are on the fire and also watch the temper drawing on others) and allow the temper to draw on its own accord, if there is plenty of heat left in the chisel back from the hardened part although dipped 1¾ inches into the hardening bath, the temper will often draw showing a light blue color 1¼ inches back from the cutting edge, but if the temper does not draw quite to the necessary color on its own accord hold it over the fire. When heating the chisels for hardening after this method let the helper (if you have one) keep the chisels placed on the fire in order that they may be continually heating, as others are taken away to be hardened, "but do not trust the helper" to heat them to the right heat, as the toolsmith must watch the hardening heat himself as he is responsible for the quality of the tool. With a good helper, the author has dressed, hardened and tempered from 15 to 20 flat cold chisels per hour after the method already explained, and every chisel guaranteed to give the best of satisfaction by chipping as hard steel, as the chisel is made from.

When dressing granite cutters' tools, keep 3 or 4 in the fire gradually heating and as one becomes hot enough to dress, dress it and return to the fire to heat for hardening (as granite tools do not require to be heated very far back from the cutting edge, when hardening they can be heated very quickly), when hot enough to harden, quench it deep into the hardening bath, then rub it across the sand board to brighten, afterwards placing it on a piece of sheet iron or tin attached to a tub of water (not the hardening bath) and allow the temper to draw on the tool by its own accord, as granite tools do not require much temper, very little heat left in the tool after quenching will be sufficient to draw the temper to the desired color, and as the temper becomes drawn in a tool push it off into the water to cool off. After a little practice and having all the tools, etc., placed in a very convenient position, 50 to 60 tools such as points, chisels, and small drills can be dressed, hardened and tempered, in one hour.

When hardening and tempering a great many small machinist's or riveting hammers, harden both ends at once by holding the hammer in an upright position and reversing the ends of the hammer back and forth into the fire (thus heating the ends hot enough to harden, but keeping the eye of the hammer soft), then plunge the whole hammer into the hardening bath and cool off entirely, then polish bright. To draw the temper, heat a large iron block (say 6 inches square and 4 inches thick) to a deep yellow heat, now place the hardened hammers across the corners of the heated block, having the eye directly on the block and so allowing the ends to project out from the heated block as shown by dotted lines, Fig. 116. By this method of

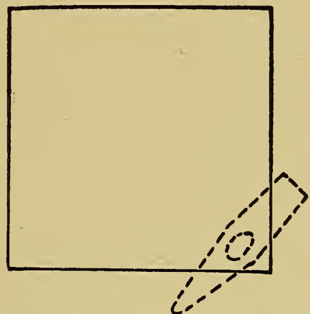


Fig. 116. Illustrating quick way of tempering small hammers.

tempering small hammers, the temper will draw in the eye first if the hammer is turned over occasionally, afterwards the temper will draw in the ends, by keeping 4 hammers on the block at once they can be tempered very quickly. If one end of a hammer should draw the temper before the other cool it off, but not any further back than the eye, then place on the heated block again until the temper is drawn in the other end.

When forging tools, keep your hand tools well arranged in a very convenient place close to the anvil and so be able to put your hand on the tool at once (which is required) and save lifting or moving a great many other unnecessary tools.

Cracks in Steel.

Anyone who has had any experience working steel or making tools has noticed cracks in the steel as shown in the cold chisel, Fig. 117. These cracks are often called "water cracks" and some will say the water was too cold, but the real causes are having the steel too hot when hardening and unevenly forging the tool at too low a heat, and if the tool has been forged at a very low heat then overheated when hardening, cracks in the steel are almost sure to be the result. Any tool that has a crack in it, no matter how small, will break very easy when put in use.

Slighting Tools.

Any toolsmith who wants to do good work in order that he may gain a good reputation cannot afford to be careless or slight the tools he is to make or repair, but should at all times do the work to the best of his ability. When dressing cold chisels as the one illustrated in Fig. 117 (or any similar tool) do not attempt

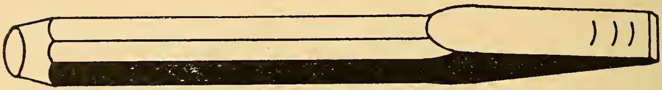


Fig. 117. Showing cracks in cutting edge of a cold chisel.

to dress it by leaving the cracks in it, but cut off the end of the chisel as far back as the cracks are visible in the steel.

A steelworker should never get in the habit of doing much talking while a piece of steel is heating in the fire, and more especially if the steel should be heating to be hardened, a great many expensive tools have been entirely destroyed by doing too much talking, thus causing the toolsmith to forget his work. If you have a lot of talking to do which is apt to draw your attention away from the fire, take the steel out of the fire and lay it to one side until you are through with the conversation, as there is no work which demands closer attention and greater care than successful toolmaking. Also, do not get excited when working steel, as no one can work steel successfully if he is of an excited and nervous nature and never attempt to make tools when under the influence of strong drink, to work steel successfully the steelworker must have a clear brain and be patient, careful and have a quick and decisive judgment.

The Result of Being a Successful Steelworker.

The keynote of being a successful steelworker is "economy," and any large manufacturing company having in its employ an expert steelworker will be a great amount of money ahead at the end of a year, this result caused by the saving of steel and also labor. For example, I have been in large manufacturing establishments where they had a poor toolsmith in their employ, and the results were, a great many mechanics were losing time going back and forth to the tool fire in order that they might get a tool to do good work. I have known machinists and others to go to the tool fire 3 or 4 times (while once is enough) before they would get a tool to do its work, and in some cases they never got a first-class tool.

Not only is the result of being a successful steelworker or toolsmith a great saving to the firm or company he is employed with, but a saving of a great amount of unnecessary work and trouble to himself. A first-class toolsmith will keep a much larger gang of mechanics at work, when placed beside a toolsmith whose knowledge concerning steelwork or toolmaking is very limited.

Hardening Tools That Are Forged By Another Mechanic.

No blacksmith or steelworker should assume the responsibility of hardening tools (especially if expensive) that are forged by another mechanic, for if the tool should crack when hardening (or in any other way not prove satisfactory) the blame will fall on the mechanic who hardens the tool, although the one who deserves the blame is the man who forged the tool, as he left strains in the steel by irregular heating and irregular hammering. It does not signify how expert the hardener may be, as the steel is still bound to crack if not forged properly.

Sayings and Ideas of Mechanics in Reference to Steel.

Steel is one of the greatest and favorite subjects for discussion among mechanics, and the consequence is a great many different theories, sayings and ideas arise in their minds as to what they think is the best way of working it, and the toolsmith is in a position to hear the idea of each mechanic when wanting a tool made or repaired. But the toolsmith must do as he thinks right as regards the working of the steel, but as to the shape of the tool he must follow the mechanic's instructions. For example, I will give a few of the sayings and ideas which I have gathered up at the tool fire, although other sayings are mentioned in this book. Some mechanics have a habit of trying a tool with a file before using it, and not long ago I made a chisel for a machinist. After I had it made he took it away and in a few minutes returned with the chisel filed to an edge. He came up to me and said, "This chisel is no good because I can file it!" I asked him if he had tried it. He said, "No, there is no use of me trying it when I can file it so easy!" I told him to go and try it. He went and tried it and was convinced that the chisel would hold a good edge although he was able to file it. Now I wish to say to anyone who uses a cold chisel, although a chisel will chip cast steel and at the same time hold a good edge, it can be very easily filed to an edge with the use of a new or sharp file.

An idea with a great many so-called steelworkers is, they will say, it does not matter how hot steel is heated (so long as it is not burnt) when hardening, if it is put in the water at a cherry red. Now I wish to say in reference to this idea, although the result will not be as bad, neither will the steel be so liable to crack as when quenching the steel at a deep yellow or white heat, but the steel will never be in a fine crystalized state or hold a keen cutting edge as a piece of steel heated to the proper hardening heat, which is mentioned so often in this book. Again, steel should never be held in the air to cool off after it leaves the fire when it is to be hardened, so bear in mind when hardening steel to quench it in the hardening bath directly after it leaves the fire, and have the hardening bath as close to the fire as possible and in a convenient place.

Forge steel at a low heat is an old saying of a great many, and likewise a great many blacksmiths believe it and so forge the steel at a cherry red heat. I have already mentioned about the dangerous practice and hard work of forging steel at a low heat, but for the benefit of any reader who is connected with the working of steel, I will give this information, trusting it will be well remembered. Forge cast steel in the beginning at a deep yellow heat, and if the steel is heated to a white heat (so long as it is not burnt) it will be all right, but lessen the heat as the tool nears the finished stage, all tools should be finished at a very low heat, especially all edged tools having a flat surface.

Never upset cast steel is another old saying of some steelworkers, and when they are asked the reason why they will generally reply, "It opens the grain and spoils the steel," and I have known some blacksmiths who refused to make certain tools, saying to the customer the steel was not large enough without upsetting and that would spoil the steel. Reader, upsetting spoils the steel is an old saying, but that is all there is to it, as there is practically no foundation in the theory and there is positively no grain in steel. Sometimes there happens to be seams lengthwise in the bar but that is a fault of the manufacturer. A piece of good steel may be said to resemble a piece of putty, which can be worked in any way and still produce the same results so far as the grain is concerned. The author has upset steel to three times its original size and when finished gave as good satisfaction as if it had not been upset at all. But to more fully explain, take a piece of octagon steel and make it into a chisel and when made the chisel is found to cut first class, now what is to hinder us from making a chisel on the opposite end. There is simply nothing at all, "and yet we are upsetting it, as drawing the steel out on one end is working the steel in the same direction as upsetting it in the other end. Now, reader, remember this: A cutting edge can be put on the side of the octagon bar and still stand as well as if put on at the end; also the steel can be upset, crooked or bent any shape or form and still hold a first-class cutting edge when properly worked.

Why Some Tools Are Soft When Put Into Use.

There are different reasons for tools being soft when put into use. However, the main reason is, the tool has not been hardened successfully as the steel was not hot enough when quenched into the hardening bath, and if the steel has not been hardened it matters not whether any temper is drawn or not the tool will be soft just the same. Another reason why a tool is often said to be soft by some mechanics when bringing it to the toolsmith to be repaired, is because the tool has been used on hard cast iron while the tool was not tempered to cut anything harder than ordinary cast steel, consequently the cutting edge turns over when coming into contact with the hard metal.

Still another reason, although the tool may be hardened and tempered properly, it is quite a common occurrence that the temper is drawn when grinding on an emery wheel.

Reasons Why Tools Break When in Use.

A few of the main reasons why tools break when in use are—overheating of the steel when hardening, and improper forging which will cause cracks in the steel, also by leaving the temper too high, making the tools too thin and using a poor quality of steel. Another reason for tools breaking is the result of putting tools to a use for which they were not intended. For explanation, I have had mechanics bring me broken cold chisels (and having made the chisels myself, I could certify that they were forged, hardened and tempered correctly) and when I would make inquiries to ascertain how the chisels were broken, the mechanic would say he was using them for wedges. Very often the toolsmith worries and so keeps himself in hot water when broken tools come to him to be dressed, as he thinks he is to blame because he thinks he did not make the tools properly. This is a great mistake on the toolsmith's part, for in a great many cases the mechanic who is using the tools is to blame, for if a tool is put into a use for which it is not intended or used carelessly it does not signify how well the tools are forged, hardened or tempered, they will break just the same, and for the benefit of every blacksmith or toolsmith who chances to get a copy of this book, I say follow the instructions closely concerning each tool, and then if the tools are broken when in use 9 cases out of 10 the fault will lie with the mechanic who was using the tool. When a tool is broken look at the fracture of the break, if it presents a close grain resembling a piece of glass the tool has been hardened properly. But, instead, should the break present a very coarse fracture resembling somewhat a piece of honeycomb, the tool has been improperly hardened by overheating, and in a case of this kind the toolsmith is to blame for the tool breaking. Tools used in very cold and frosty weather will break much easier than in warm weather, especially if used outside in the open air.

Necessary Tools.

I have often strolled into a country or general blacksmith shop and found the blacksmith trying to forge a piece of neat work, by using simply a hammer and the anvil. It is quite possible that a great amount of work can be accomplished with only a hammer and the anvil, but the work is limited and very often after forging the article as near the shape as is possible, the blacksmith will often wear out a new file by filing the article to the finished shape, while the money that he pays out for files would soon amount up enough to buy him a good outfit of anvil tools or pay him for the time it would take to make them. By having a good outfit of tools, a great many jobs can be done in half the time and give a much neater appearance. The most necessary tools required in the ordinary blacksmith shop, aside from a good anvil and hammer are tongs for holding different shapes and sizes, fullers and swages ranging in size from ¼ inch to 2 inches, a flatter, set hammer, a hot and cold chisel, and a hardy. Of course there are a great many useful tools that I could mention, such as are used in large and up-to-date shops, but in a small shop it would not pay to keep them all on hand. However, the ones already mentioned should always be kept on hand. Any blacksmith who is employed in a large machine, locomotive, or any large shop, should always be on the lookout to have as good an outfit of tools as anyone else in the shop, and so save borrowing from another fire. Although in some cases it is necessary to borrow, but when borrowing tools from another fire bear in mind to take them back as soon as possible, otherwise it may cause trouble.

Welding Compounds.

There are a great many different kinds of welding compounds, but the kind that is most extensively used and most commonly known is borax. The borax should be crushed to a fine powder to have the best results, and if wrought iron drillings (that are very fine and free from oil) be mixed it will increase the welding qualities of the borax by causing the steel to unite more readily.

Although all the instructions that I have given in the previous chapters (in reference to welding) is with the use of borax, there are other compounds which I have used with great success. A welding compound that I will recommend to the reader is the Climax, manufactured by the Cortland Welding Compound Co., Cortland, N. Y. This compound is very valuable when welding steel, especially when taking separate heats, as the steel will unite very readily and not slip away as is sometimes the case when using plain borax. When using the Climax Welding Compound be sure and follow the directions given by the manufacturer and also the instructions that I have given in this book in reference to the welding heat of steel.

Hardening Compounds.

There are many kinds of compounds used for hardening steel and most of them are of no value. Some blacksmith will have a certain compound which he says will toughen the steel, another will say he has something that will improve the steel, while others think, no matter how the steel is worked or heated if it is only dipped in some wonderful liquid kept in a fancy pail or bucket the steel will be all right, and some have said to me in my travels, "If I knew what you had in the bucket I could make the tools stand as well as you." To explain, I happened to be in a country village and asked the village blacksmith to let me have a fire which he was not using, as I had some mill picks, axes and chisels to dress. Well, I went to work and put some salt into a bucket of water, but as I wanted to have a joke on the blacksmith, I had the salt in different sizes of paper bags, so of course as I was emptying the different papers the blacksmith and his apprentice were watching me very closely, and as they had heard I was coming to the shop they wanted to learn all they could. However, I went to work and dressed the tools, occasionally showing the blacksmith what they would do, then I went away and left the brine in the pail as I was not expected back again. The next day the story was circulated that I went away and left the mixture in a pail, and the village blacksmith could temper tools now as well as I, consequently some of his customers heard of it and they were taking him some tools and he soon had a large number of tools to dress. But a few days after I happened to be in the same village and so I called into the blacksmith shop to have a conversation. The blacksmith not expecting me, I caught him at work on some tools that had just come in to be dressed, and after taking a look around the shop I saw some other tools that the blacksmith had dressed, but they were returned to him to do over again, as they were broken. Not only were the tools broken and giving poor satisfaction, but the blacksmith was getting himself in hot water by spoiling his customers' tools and trying to do something which he did not understand. This may look like a fish story to the reader, but nevertheless it is quite true and I could relate other such happenings.

Now, reader, there is positively no witchcraft or common sense connected with hardening compounds, as they neither toughen or improve the steel; not only are they of no value, but the blacksmith would need almost a drug store to mix some of them, while the blacksmith works too hard for his money to spend it on such rubbish. The best hardening compound is simply clean cold water and salt to form a brine; the water should contain as much salt as the water will soak up or dissolve. This is the best compound yet discovered to harden steel at a low heat, and, reader, bear in mind that the lower the heat which steel can be hardened at the tougher it will be, and this is one of the greatest secrets connected with toughening steel. Keep the hardening bath as clean and as cold as possible. Water and brine are the only two hardening compounds used by the author.

How to Determine the Temper of Tools.

As much information could be given regarding the shape of the tool as the temper, and if tools are to be made to cut or work on material that is not mentioned in this book, it would be best to find out what hardness the material is also if the tool is to do its work by steady pressure as a lathe tool or by a blow from a hammer as a cold chisel. If the tool is to do its work by striking it with a hammer, it must be ascertained how heavy the blow is to be. For example, if the tool is struck very lightly, although the tool is to chip very hard material, it can be drawn out very thin, but if the blow is very heavy the tool must be made heavy and thick accordingly, to stand the force of the blow.

When making tools to work on strange material, it will be best to make them on the thick and temper them on the soft side, after which the hardness of the temper can be increased and the thickness of the tool reduced to whatever gives the workman (who is to use it) the best satisfaction. If it should be otherwise by having the tools drawn out too thin and the temper left too hard, causing the tools to break very easy, there will be a good many chances to one if the blacksmith or tool dresser does not lose his job, so make sure and be on the safe side in the beginning. To more fully explain: I have known blacksmiths to take jobs sharpening granite cutters' tools, and although the tools were hardened and tempered first class they were drawn out too thin, consequently the tools were easily broken, as the hammers used by ordinary granite cutters are very heavy, and likewise the blows that are struck upon the tools "are very heavy," and as granite tools require a hard temper in order to cut or chip the stone, the only method to fall back on for safety is to increase the thickness of the tool by not drawing it out so thin.

There are times however when it is quite a difficult problem to determine the correct temper. Take for example, the toolsmith who is making or dressing the chisels in a large locomotive shop, when a large number of chisels is brought to him to be dressed at one time, he does not know if a certain chisel is going to be used in the erecting department or at the motion bench. A chisel used in the erecting department has to stand a great amount of rough usage by being used for a wedge, but does not chip any hard material more than splitting iron nuts, this chisel when dressing (and its use is understood) should not be drawn out so thin as a chisel that is to do fine chipping, and it may be classed as the ordinary chisel (see chisel No. 2, Fig. 16, shown in another chapter of this book). The temper should be drawn to a very light blue almost a grey. But a chisel used by a machinist at the motion bench can be drawn out very thin (see chisel No. 1 of the same figure as just previously mentioned).. The reason why this chisel can be drawn out so thin, is because the machinist as a rule is an expert in using a chisel, as he strikes it squarely on the head and holds it firm to the material he is chipping, consequently the temper "can be left harder" without fear of the chisel breaking.

Overheating Tools.

If at any time tools of a flat surface such as cold chisels, axes, etc., become overheated when hardening, never attempt to quench the tool in the hardening bath while the steel is at such a high heat but rehammer it at a low heat equally on both sides, then the tool is all right again to be heated to harden. Should the tool be quenched or hardened at such a high heat, it is very apt to crack while hardening or it will break very easy when in use. Tools of irregular shape such as milling cutters, taps, dies, etc., cannot be worked over again with the hammer, consequently great care must be exercised when heating to harden or the tool will be ruined, but if the tool is not heated hot enough to harden the first time no harm is done and it can be heated again to a little higher heat.

Cutting Steel When Cold.

Cutting the steel cold is a very satisfactory method, when bar steel is to be cut or broken into certain lengths, as when making cold chisels or other similar tools but the advantage of this method will cease when cutting steel over a certain size. For example, octagon, round or square cast steel ranging from the smallest size up to 1¼ inches in diameter, can be broken very quickly and satisfactorily when perfectly cold, by nicking the bar equally from all sides, afterwards placing the nicked part of the bar directly over the square hole of the anvil, then striking it with a sledge when it will break. But care must be exercised when breaking steel after this method, as the pieces are very apt to fly and strike the blacksmith or his helper, but to overcome this danger place the handle of the chisel on the piece which is to be broken off before striking it with the sledge, which will prevent the piece from flying. When nicking the steel, hold the chisel so as to cut in a straight line and so enable the steel to break off square on the ends.

To enable the steel to break with greater ease pour a little cold water directly on the nicked part of the steel. By pouring cold water on the steel all the heat is taken out, as steel will break more readily when perfectly cold than when it is warm.

Breaking a bar of steel cold, is a very good way of finding out the hardness or the quality of the steel, for example take a bar of ¾ or ⅞ steel (after being nicked) if the steel breaks with one or two blows from the sledge it denotes hard steel, but soft steel will require five or six blows before it breaks; also hard steel (by looking at the break) will show a fine and close fracture, but the fracture of soft steel will be more coarse and rough. If the steel is of good quality, the break or fracture will show a very uniform and silvery white appearance clear through the bar, but if the steel is of a poor quality it will show a dull brown appearance.

To test steel bars that are too large to break cold, for example a bar two inches in diameter, heat the bar to a deep cherry red, then cut in from all sides say half an inch deep with a hot chisel, then lay the bar down to cool and when it is perfectly cold it may be broken by striking it with a sledge or dropping the bar over the anvil and the quality or hardness can be judged as formerly explained. But bear in mind that the steel must not be heated above a deep cherry red (in order to cut in the nick) or the fracture when broken cannot be judged correct, as a high heat in the steel would materially change the appearance and form of the fracture. I also wish to add, when cutting a great amount of cold steel at one time, dampen the cutting edge of the chisel with oil; again, if used with care the chisel may be tempered to a purple without danger of breaking if made from steel of the proper hardness.

Oil Tempering.

Oil tempering, although often talked about, is a process little understood by the average blacksmith or steelworker and a great many mechanics have the idea that oil tempering is simply cooling off the steel in oil after the temper has been drawn. But to those whose knowledge is very limited as regards oil tempering, I will give the process, thus: In some large tool factories where tempering by colors is done away with, the temper is drawn on the tool after hardening by placing it in a vat of heated oil, the temper can be drawn to any degree according to the degree of heat the oil is heated to, which is registered by a thermometer attached to the vat.

Oil tempering does not refine the steel in any way as some mechanics think it does, but it has an advantage in this way, the temper can be drawn very evenly to any degree, also when drawing the temper in oil the steel does not have to be polished.

Drawing the Temper over the Open or Blacksmith's Fire.

The method of drawing the temper on tools over the fire is a very useful one, although a great many blacksmiths or tooldressers are not acquainted with it, as they think the only way is to let the temper run down on its own accord. I have already explained the method many times in this book, but there are a few ideas I wish to add. Of course the work that can be accomplished by this method is limited to a certain class of tools; take for example tools that are partly hardened, such as cold chisels, axes, or any similar tools.

Very often a tool is dipped a little too deep in the hardening bath, consequently there isn't enough heat left in the tool to allow the temper to run down on its own accord to the desired color, and so the necessary temper must be drawn over the fire if the best results are to be expected.

When drawing the temper over the fire be careful not to have too much blaze (better still to have no blaze), and do not have a smoky fire if it can be avoided, but in case the fire is smoky have a piece of cloth made stiff by winding around it a piece of fine, pliable wire, so that when drawing the temper, occasionally brush the tool with the cloth (where the temper is to be drawn), which will take off the smoke and keep the tool bright, and also allow the temper to be seen and drawn with greater ease and exactness. Again, when drawing the temper over the fire, do not hold the tool too close, but hold it about two inches above the surface of the fire. Also bear in mind, do not give the fire too strong a blast (just enough to keep the fire bright is plenty), as it will draw the temper too quickly on the extreme cutting edge first. Do not hold the tool perfectly still when drawing the temper as there may be a hotter spot in one place in the fire than another which would draw the temper in streaks, but move the tool sideways or lengthways back and forth whichever is best to suit the shape of the tool, until the temper is drawn very evenly.

If one side of a tool is seen to be drawing the necessary temper first, lower the other side nearer to the fire; this information will apply more especially to tools having a wide and unequal shape. Also when drawing the temper on tools, such as round punches or any similar tool that are partly hardened, keep the tool slowly and continually revolving around, in order to draw the temper very evenly on all sides. Otherwise if a round tool is held perfectly still over the fire, one side will draw to a blue while the opposite side will only heat to a straw color, unless the tool is very small.

More Points on Hammering Steel.

When hammering steel in the finishing stage to refine it, bear in mind to forge the tool as near the shape or size as possible while the steel is at a bright yellow heat, but leaving the tool a trifle large or thick, as the tool will naturally require a little stock in order that the tool will be the right width or size after being hammered. This information will apply more particularly to tools of a flat shape.

Too much hammering is not good for steel, for example, supposing the toolsmith has a flat cold chisel to draw out. He draws out the chisel and hammers it in the finishing stage to refine the steel. Now after the chisel has been drawn out to a certain thickness and hammered sufficiently, the toolsmith decides he will have to draw the chisel much thinner as he has been informed the chisel is to do some very fine chipping. But I want to say to the toolsmith right here, do not draw the chisel thinner by continuing to hammer it at a low heat, because it will have a great tendency to cause strains in the steel, which would result by cracking when hardening. But to draw the chisel thinner, heat it again to a bright yellow heat, then draw out to almost as thin as is required, then finish by hammering it as before.

Do not attempt to bend cast steel at a dull red or black heat after it has been hammered, as that would destroy all the tenacity put in the steel by hammering. If the steel is to be bent after it has been hammered, heat the steel to a cherry red heat, although a certain amount of the tenacity will be destroyed, yet not enough to injure the quality of the steel. But if the steel should be hammered, then bent at a black heat or otherwise should it be bent at a white heat, then all the toughness has been taken out of the steel. This information will apply to fine flat springs that sometimes have to be bent to the correct shape after the hammering has been done, and will also apply when bending lips on flat drills.

The correct heat for hammering steel so that it will be refined and made tough, is a dull red heat, but do not hammer steel after it becomes black, because if the steel is hammered after it becomes black it will be brittle and flakey, which will cause the cutting edge of the tool to break more easily when put in use.

Very often cold chisels or similar tools are brought to the toolsmith to be hardened and tempered which were forged by another mechanic whose knowledge concerning steel was very limited. Now "if the best results are expected" do not simply harden and temper the chisel, as the chisel must likewise be hammered. But the toolsmith will say the chisel is already drawn out thin enough, but we will suppose it is, heat the chisel to a bright cherry red heat and upset it a little, which will give a little stock to allow it to be hammered to the right size again, also, by upsetting the chisel will help to take out any light strains which may have been put in the steel by the man who forged the chisel.

Again, when hammering steel do not use too light a hammer as it is only time lost. A hammer weighing two pounds is plenty light enough, and when hammering cold chisels (unless very fine) always strike level and as hard as you can, in order to pack and refine the steel sufficiently. Bear in mind when hammering tools that have a flat surface for the last time, never strike one blow edgewise but strike every blow on the flat surface and both sides the same.

How to Improve.

Improvement is the gateway of true success in every art, trade or profession, and which applies especially to the toolsmith. To improve, the toolsmith must be devoted to his work and give it his whole mind and attention, as no toolsmith will ever be a successful steelworker, if he allows himself to become discontented by thinking that some other business or trade is better than his own, or if he only works at his own trade to make a living, and consequently all the time looking for quitting time and payday.

To the toolsmith who is determined to improve and be in the front rank, I wish to give this advice, first of all read and study this book from beginning to end, do not simply read it once but read it many times until you have the contents almost by heart, and put the instructions into practice. If you are making or dressing any tool that is mentioned in this book and it should happen to break or in any other way not give satisfaction, somewhere in these pages you will find the cause of your trouble. But if you are making a tool not mentioned in this book and it should break, find out the reason it broke, also find out how the tool does its work and if there is a weak point in the tool. Very often a tool will break, although it is made from the best quality of steel and it is properly forged, hardened and tempered, and so always remember to make a tool that is apt to break as strong as possible in every way, and do not temper the tool any harder than "just enough to do the work."

Again, when trying to improve do not accept the advice of every Tom, Dick or Harry as being the best way, without first giving it a trial, no matter if the advice "does come" from the foreman, superintendent or the master mechanic. The manager of the company whom you are employed with may be competent to run the business successfully, but remember, in 19 cases out of 20 he knows nothing about steel from a practical standpoint, with the exception of what he has been told. The toolsmith who takes everybody's advice without giving it a trial by trying to please everybody, will never improve or meet with success. To improve and become an expert toolsmith, learn all you can about working steel, as it is better in these days of great competition to be master of one trade than a Jack of all trades. Never say to yourself I can't do this job or I can't do that, but go ahead and try; do your best and if you fail, always try again until you accomplish the work in a first class and satisfactory manner. Bear in mind that success is reached by overcoming difficulties. The author has had many a hard trial and difficulty to overcome connected with steel, but by hard work, deep study and perseverance has been crowned with success.

The Blacksmith's Helper.

A willing and intelligent helper is a great help to any blacksmith, and very often the work can be accomplished with greater ease and quicker than if a blacksmith has a don't care and a dull minded sort of a fellow for his helper, and for the tool fire the helper should be fully up to the average for intelligence.

I know helpers who have better ideas concerning how the work should be done than a great many blacksmiths themselves, and very often a blacksmith has been greatly indebted to his helper for certain ideas. No blacksmith should have a helper whom he has got to be teaching or telling all the time how to strike, neither should a helper be helping an overbearing blacksmith, as I have known some blacksmiths to be changing helpers every week or two, because the helper would rather lose his job than help a blacksmith who was continually using him more like a machine than a brother shop mate. I have had helpers helping me on the tool fire from one year's end to the other, and

I always treated my helpers as I would like to be treated myself and often forming a close and lasting friendship. And to all my brother mechanics I wish to say, treat your helper as you would like to be treated if you were in his place. Do not use him like a slave by making him do heavy striking when it is possible to do the work under the steam hammer.

The Danger of Heating More of a Tool When Dressing Than What is to be Forged or Hammered.

To explain this subject fully, we will suppose a cold chisel is heated to a high yellow or white heat two inches back from the cutting edge, but it is only forged or hammered one inch back of the cutting edge. Now if this chisel should be hardened two inches from the cutting edge, it would break very easy just back of the hammered part, when put in use, for this reason. If steel is once heated to a very high heat and not forged or hammered but hardened, although it should be hardened at the proper heat, it does not become crystalized the same as when forged or hammered. Also, when the steel breaks at the unforged part, the break will present a very coarse fracture resembling a piece of overheated steel, so bear in mind to forge or hammer all the steel that is heated to a high heat, especially if it is to be hardened. If the steel is not to be hardened, it is not necessary to be so particular in working all the heated steel, although steel is always stronger when finished at a low heat whether it is to be hardened or left unhardened. This information will apply directly to small granite hand drills, where only half an inch back of the cutting edge can be worked with the hammer, and so when dressing small granite hand drills (or any similar drill) be careful not to heat to a high yellow any farther back from the cutting edge than ⅜ of an inch. But when dressing a large hand drill such as a miner's hand drill, it will have to be heated according to the size.

Hardening Very Small or Thin Tools.

When hardening very fine tools, have a small can of cold water or brine placed as close as possible to the fire, then the tool can be quenched immediately after it leaves the fire. Otherwise very thin tools will not hold the necessary heat (which is required to harden them successfully) long enough to reach the ordinary hardening bath.

More Information About Cold Chisels.

Although I have given more information concerning a cold chisel than any other tool mentioned in this book, I have done so because there is no one tool which requires so much science or skill as a cold chisel. I know some toolsmiths who have worked steel for forty years and yet never learned to make a cold chisel that would chip any material harder than ordinary cast steel and even then it was only guess work. Now, reader, I want to impress deeply on your mind, that cold chisels can be made to chip from the softest known material up to the hardest of chilled metal, but the chisels to do this work successfully must vary in softness or hardness of temper according to the hardness of the material to be chipped, and also vary in shape according to the weight of the blow struck by the hammer. There are a great many mechanics who think there is some way of making and tempering a cold chisel so that it will chip everything without breaking or being too soft. This is a great mistake, as it is impossible for one cold chisel to chip every kind of material and at the same time give satisfactory results. Instead we must have a number of cold chisels and each one made for a certain use.

The different shapes of chisels as illustrated in another chapter of this book, will be found to give the very best results if made according to the instructions and each chisel used for its own particular purpose. Blacksmiths and ordinary tool dressers as a rule never take the shape of a chisel into consideration; consequently, they will very often make a chisel very thin when it is required to be made thick or vice versa. When making chisels or any other tool, bear in mind that no matter how good the quality of the steel may be or how well it may be worked, hardened or tempered, the strength of the tool is always limited, consequently a thin chisel will always break much easier than a thick one especially when given hard and rough usage. Of course the general or country blacksmith who is making chisels for farmers and others, cannot tell how the chisel is going to be used or what material it is to chip, therefore the chisel must not be made too thin or too thick; it must be medium, which I have classed as "the ordinary or farmer's chisel," and which should be tempered to a light blue.

Never temper a cold chisel above a light blue unless you know for certain it is to chip very hard cast steel or cast iron. A chisel to chip very hard cast steel of about one per cent carbon, should be tempered to a dark blue. The cold chisel No. 4 as illustrated in Fig. 16 which will be found in another chapter of this book, is used for exceedingly hard and rough chipping, the shape will also apply to long chisel bars such as are used in the erecting departments of locomotive shops, and a chisel bar for this particular purpose should be tempered to a very light blue or almost a grey, as a chisel bar does not have to cut or chip any hard material, but it is given very rough usage, consequently, it must be made with a very short taper and tempered very low in order to keep it from breaking.

Always remember that if a chisel (or any other tool) is properly hardened, the chisel will stand first class even if the temper is not drawn to the exact color. But if the chisel is improperly hardened by being overheated, it will never stand or do good work no matter what temper is drawn afterwards, so make sure the chisel is properly hardened.

Although steel of 75 point carbon is best for making all kinds of cold chisels, on account of some bars of octagon steel being much higher in carbon than others it is almost impossible to always make chisels from steel of the proper hardness, and so I wish to say to the blacksmith or tooldresser, any time you have to dress or make a cold chisel from very high carbon steel (say one per cent) harden it at as low a heat as it will harden at successfully, and always let the temper run down lower. For ordinary use, let the temper of a chisel made from high carbon steel draw to almost a grey and it will give good results, but bear in mind never make a chisel from high carbon steel when it is possible to make one from steel of the proper carbon, for this reason, a chisel made from high carbon steel will keep breaking or splitting off at the end which is struck by the hammer. When dressing cold chisels, always cut off the old cutting edge after the chisel is drawn out to the right thickness before hammering for the last time, then file or grind on a new cutting edge. In the ordinary blacksmith shop the cutting edge is filed on before tempering the chisel, but in large machine shops the cutting edge is ground on after the chisel is tempered.

The different degrees of temperature Fahrenheit required to equal the various colors when drawing the temper in hot air or oil:

Color.	Deg. of Tem. F.
Light straw	440
Dark straw	470
Copper	500
Red	520
Purple	540
Dark blue	560
Light blue	590
Grey	620

Table of ordinary tools made from cast steel, arranged alphabetically, giving the color of temper and about the percentage of carbon the steel should contain to give the best results. To understand the following table of carbon, I will explain, 0.75 is equal to 75 points, 1.00 is equal to 1 per cent, 1.25 is equal to 125 points or 1¼ per cent.

Description of tool.	Color of temper	Carbon
Axe, broad	Light blue	0.75
Axe, lumberman's chopping	Light blue	0.75
Axe, limestone tooth	Light blue	0.75
Beading tool, boilermaker's	Light blue	0.75
Calking tool, boilermaker's	Light blue	0.75
Canthooks	Light blue	0.75
Centers, lathe	Purple	0.90

Description of tool.	Color of temper	Carbon
Chisel, machinists' cold	Light blue	0.75
Chisel, ordinary or farmers' cold	Light blue	0.75
Chisel boilermaker's cold	Light blue	0.75
Chisel, blacksmiths' hot	Light blue	0.75
Chisel, blacksmiths' cold	Light blue	0.75
Chisel, railroad track	Light blue	0.75
Chisel, limestone	Light blue	0.75
Chisel, sandstone	Light blue	0.75
Chisel, ordinary granite	Light straw	0.75
Chisel, marble	Very light straw	0.75
Chisel, carpenters'	Dark blue	0.75
Chisel, brick	Light blue	0.75
Clamp, bolt	Light blue	0.75
Cleaver butchers'	Light blue	0.75
Clippers, blacksmiths' bolt	Light blue	0.75
Clinch cutter, horseshoers'	Light blue	0.75
Cutter, ordinary milling	Dark straw	0.90
Cutter, pipe	Purple	0.75
Cutter, horseshoers' hoof	Light blue	0.75
Die, ordinary threading	Dark straw	0.90
Digging bars	Light blue	0.75
Drill, twist	Purple	0.90
Drill, ordinary flat	Purple	0.75
Drill, soft rock well	Dark blue	0.75
Drill, small granite hand	Light straw	0.75
Drill, limestone hand	Light blue	0.75
Drill, limestone ball	Light blue	0.75
Drill, sandstone	Light blue	0.75
Drill, small marble	Very light straw	0.75
Hammer, granite bush	Light straw	0.75
Hammer, limestone bush	Light blue	0.75
Hammer, ordinary granite	Light straw	0.75
Hammer, machinists'	Light blue	0.75
Hammer, blacksmiths'	Light blue	0.75
Hammer, car wheel inspectors'	Light blue	0.75
Hardy	Light blue	0.75
Hatchets, woodworkers'	Light blue	0.75

Description of tool.	Color of temper	Carbon
Jaws, blacksmiths' vise	Dark blue	0.75
Jaws, pipe vise	Dark blue	0.75
Knife, pruning	Light blue	0.75
Knife, butchers'	Light blue	0.75
Knife, pocket	Light blue	0.75
Knife, draw	Light blue	0.75
Knife, horseshoers'	Dark blue	0.75
Knife, carpenters' plane	Dark blue	0.75
Knife, harnessmakers'	Dark blue	0.75
Maul, railroad spike	Light blue	0.75
Pick, dirt	Light blue	0.75
Pin, flue expander	Dark blue	0.75
Pincers, horseshoers'	Light blue	0.75
Pitching tool, limestone	Light blue	0.75
Pitching tool, sandstone	Light blue	0.75
Planer tool, soft stone roughing	Light straw	0.90
Planer tool, ordinary machinists'	Copper	0.90
Pliers, wire	Light blue	0.75
Point, granite	Light straw	0.75
Point, limestone or sandstone	Light blue	0.75
Punch, boilermakers' hand	Light blue	0.75
Punch, nail	Light blue	0.75
Punch, boilermakers' machine	Light blue	0.75
Punch, saw gumming	Dark blue	0.75
Punch, ordinary center	Dark blue	0.75
Razor	Purple	0.75
Reamer, ordinary	Purple	0.90
Rolls, flue expander	Dark blue	0.75
Scraper, wood	Purple	0.75
Screwdriver	Grey	0.75
Set, nail	Light blue	0.75
Set, bricklayers'	Light blue	0.75
Shear blades	Dark straw	0.75
Snap, boilermakers' rivet	Light blue	0.75
Spring, gum (see springs as illustrated)	Very light blue	0.60

Description of tool.	Color of temper	Carbon
Spring, trap (see springs as illustrated)	Very light blue	0.60
Tap, ordinary threading	Dark straw	0.90
Tool, woodturners' lathe	Dark blue	0.75
Tool, ordinary machinists' lathe	Copper	0.90
Tool, stone lathe	Copper	0.90
Wrench, alligator	Dark blue	0.75

Table of tools continued, which are partly or wholly hardened but have no temper drawn.

Description of tool.	Carbon
Chisel, cold, for excessive hard metal	0.75
Chisel, stonecutters', for very hard granite	0.75
Cutter, milling, heavy formed	0.90
Cutter, milling, for hard metal	0.90
Dies, forging machine	0.75
Drill, large hand, for granite or hard rock	0.75
Drill, miners' cross, for granite or hard rock	0.75
Drill, well, for hard rock	0.75
Drill, machinists' flat, for very hard material	0.90
File	1.00 to 1.25
Hammer, stonecutters' mash	0.75
Hammer, ordinary stone	0.75
Pick, mill	0.90
Reamer, heavy tapered, for hard material	0.90
Reamer, for granite or hard rock	0.75
Rasp	1.00 to 1.25
Scraper for cast iron or steel	0.75
Scratchawl for cast iron	0.75
Share, plow	0.75
Stake anvil, for dressing stonecutters' tools	0.75
Steel, butchers'	1.00
Tool, machinists' lathe, for hard cast iron	0.90
Tool, machinists' planer, for hard cast iron	0.90
Tool, granite pitching	0.75
Tools, stone carvers' fine	0.75

To Anneal Hard Steel.

Heat to cherry red and bury in dust or ashes to cool slow. Never let steel lay in fire any longer than possible.

To Harden Tools or Steel.

Always heat steel slow in charred coal. Charcoal is best. Green coal will ruin cast steel. Hot lead is very good to heat steel in.

To Heat Steel for Hardening or Tempering.

Take an iron box or piece of heavy gas pipe, put tools in, pack charcoal around them, heat box or pipe until tools get heated in center, then dip tools in solution.

For flat piece, knife, bit or blade, always heat on edge. If you lay flat on fire you will spring it, and for flat piece, blade, bit or knife always dip toward the north.

For heavy round piece, stir water to a whirl, then plunge tool in center of whirl. It will not spring.

GUIDE FOR HARDENING - - CHART A.

High steel (tool steel) heated, quenched in water and kept there until cooled will be hardened and refined (small crystals).

Resulting Hardness.	Heat Used.	Appearance of Fracture.
Excessively hard; almost brittle.	High Yellow.	Coarse grain, with fiery lustre.
Too hard for use; will break easily.	Yellow or Orange.	Grain open, but not so coarse or fiery.
Too hard for use; not strong enough.	High Red.	Grain not coarse, but with some fiery lustre.
Very hard; strong enough.	Red.	Fine grain clear through; no fiery lustre.
Very strong; hard enough except in middle.	Low Red.	Grain fine on the outside, but not in the middle.
Stronger than bar; not hard enough.	Black.	Grain same as the bar.

GUIDE FOR TEMPERING - - CHART B.

High steel, after hardening, may be tempered as desired by slowly heating it in the open fire until the corresponding color appears. If heated in oil or tallow, these colors do not appear, but indications of the right heat are as given below.

Designation of Temper.	Color of the Steel.	Temp. "F." ABOUT	Condition of Oil or Tallow.
Very high.	Yellowish White or Straw.	400	First begins to smoke.
High.	Dark Straw.	450	Dark smoke arises.
	Orange or Gold.	480	More abundant dark smoke arises.
Medium.	Brown.	500	
Mild.	Violet or Purple.	530	Thick black volume of smoke appears.
	Light or Sky Blue.	580	Oil will flash if flame is applied.
Low.	Deep or Pigeon Blue. (Lowest Temper Used.)	600	Will continue to burn.
Soft or dead soft.	Black Oxide. (Shows Red Heat in a Dark Place.) (No temper remains.)	650	

To Draw Temper.

If it is a flat piece, knife blade or bit, heat a heavy iron; lay tool on edge up; draw to dark straw color.

If it is a heavy round piece, make a heavy ring of iron, hold tool in center, draw to dark straw color.

After tools are forged never grind or file them until tempered. As carbon is on the outside, the more you grind off.

For Drawing Temper in Oil.

Better use tallow. Put tallow in pot on slow fire; put tools in tallow, and watch color of smoke, as chart indicates. The color on Chart B and color of smoke gives you the temper you desire.

For all springs do not harden, but boil in tallow until the smoke indicates blue color, then take out and plunge in cold linseed oil.

Working Steel at Night.

Considering that the author has done a great deal of toolmaking at night, the tools have never been of such a good quality or given such good satisfaction as when made in daylight. Although there is a certain class of tools which can be made with greater success than others, for example take miners' tools. These tools are as a rule hardened but not tempered. Therefore the heat in the steel can be seen more clearly at night than the different colors of the temper. Drawing the temper on tools after night is very hard on the eyesight and even then the correct color is very often guessed at. When tempering by colors (if possible at all), arrange your work so that the tempering may be done while there is good daylight, and this rule will apply more especially to the toolsmith when the days are short if the best results are required. Too much light at the tool fire is not good. When there is too much light have a blind put up at the window which will act as a shade and which will apply more especially when the sun is shining directly on the fire.

A Few Words in Reference to Burnt Steel.

There are a great many steelworkers, who are always looking for some method or compound to restore burnt steel and so for the reader's benefit, I will give the following information: The meaning of "burnt steel" is steel that has been heated to a higher heat than what it would stand, thus, when the steel is burnt it falls or flies to pieces when being struck by the hammer.

The best method the author has yet discovered is, being careful in the first place not to burn it, as an ounce of prevention is worth a pound of cure. The next best method is, cut off all the steel that is burnt, as it is only time lost trying to restore it to its natural state, and the time lost is of more value than the steel. Supposing it should be restored successfully, but bear in mind, that steel when once burnt is never as good as the steel in its ordinary natural state.

Conclusion.

In concluding this book, I wish to remind the readers that it has been written for their interest, and the author has endeavored to give all the necessary instructions and illustrations of all the principal tools used by almost every leading trade to insure the greatest success in the art of steelwork or toolmaking. I have left nothing unwritten which I thought would be a help or interest to the readers, and remember, readers, I have written this book to improve your mechanical ability and ideas, hoping thereby to help and encourage you to strive to reach the highest rung in the ladder of mechanical success.

It is not necessary to work at blacksmithing 10 or 15 years in order to do good work or become a first class toolsmith when you have this volume of information at hand. Readers, place a great value on your leisure hours, they will be sands of precious gold to you when spent in reading this book. Do not simply read "but think as you read," and the mechanic (whether young or old) who reads and thinks in this way will be well rewarded and soon rise above his peers. No doubt this book may be the cause of many an argument and some may condemn it as being untrue, but before condemning it take my advice and put the instructions into practice, and in years to come you will often thank the author for bringing this information before you. The mechanic who reads this book without putting the information into practical use will remain in the same old rut. My brother mechanic, you will never succeed unless you are willing to branch out and accept new ideas or methods. Do not get in the habit of thinking you know all about toolmaking or that no one can teach you anything more than what you already know, as the author takes second place to none in the art of general steelwork, yet he occasionally gets a new idea or a quicker method from some inferior mechanic. The author has written this book in order to illustrate the most up-to-date methods but if the reader (after reading) still fails to put the information into practical use or even give the different methods a trial, then he will not benefit by the reading of this book, and the author has failed in his attempt to instruct him. Bear in mind that toolwork is the very best part of blacksmithing and the blacksmith or tooldresser in any machine shop, stone yard, quarry or mine who happens to be a first class steelworker, holds the respect of all and his services are always in great demand, so reader why give up all your hopes of becoming a successful steelworker? Your chances are equal to that of the author's. He had no one to give him a word of encouragement. Neither had he a book as complete as this to help him overcome his difficulties in connection with steel, so reader let your determination be to press on and overcome every obstacle which stands in your way. Make use of all the brains which God has given you and let your ambition ever be to rise and take the lead. Your success is sure if you do your best.

Do not be given to be always telling others what you can do but keep your tongue quiet and your eyes open and always be on the alert to gain knowledge in connection with your trade. If you are a first class mechanic your customers will judge your workmanship and give you a reputation, and remember, reader, a good reputation is worth striving for even if you gain it slowly. The author well knows the worth of a good reputation which he has gained slowly by the combination of hard work, deep study, close observation, a vast amount of experimenting and wide travel. Reader, the contents of this book is the author's reputation, so make sure and combine the contents of this book with your own practical experience.

In drawing this book to a close, the author trusts and hopes that every reader (who is connected with steelwork) will be greatly assisted and placed on a foundation for future success. I have not merely written this book to improve your mechanical ideas and instruct you in the art of toolmaking, but I have written it for the sake of the love which I hold for my brother mechanics. I have placed my whole heart in the work in order that others may share with me in the joys of mechanical success. Some readers may think I have been rather sarcastic at times, but if I have been it was only in reference to a certain class of mechanics, in order to point out to them their mistakes and thereby illustrate the difference between the right and wrong ways and also the difference between good and poor tools.

My closing advice to the reader is, when you are making tools that have a cutting edge, make sure that they are hardened at the right heat. Hardening steel at the right heat is the most important obstacle to be overcome in connection with the art of toolmaking, for no matter how good the quality of the steel may be or how well it is forged, the quality and success of a tool will always depend on the proper heat for hardening. Again, always remember to do your work to the very best of your ability, and follow closely the old adage, "whatever is worth doing, is worth doing well," and you will soon become master of the "king of metals."

THE AUTHOR.

USEFUL FORMULAS.

Tempering Brass.

No. 1. Brass is rendered hard by hammering or rolling; therefore when you make a thing of brass necessary to be tempered, prepare the material before shaping the article. Temper may be drawn from brass by heating it to cherry red and plunging it into water.

To Case Harden Set Screws for Shafting.

No. 2. Melt piece prussiate potash the size of a bean on spot you want hard while it is hot and plunge into water or linseed oil.

To Case Harden any Particular Spot, Leaving Other Spot Soft.

No. 3. Make a paste of concentrated solution of prussiate of potash and then coat the spot you wish to harden; then expose to strong heat. When red hot, plunge into cold water.

To Case Harden Cast Iron or any other Iron.

No. 4. Three parts bichromate of potash; one-half part common salt. Pulverize well and mix. Heat iron to highest heat it will stand; then sprinkle on mixture and try well on both sides. Cool in water.

To Case Harden Steel.

No. 5. Use one part oxalic acid and two parts of pulverized common potash. Pulverize them well and thoroughly mix. Heat to cherry red, then roll in mixture as you would in borax, then heat again in clear fire; cool in water.

Composition to Convert the Most Impure Scrap While in Ladle to No. 1 Castings.

No. 6. 8 pounds of Copperas.
3 pounds of Zinc.
½ pound of Tin.

Throw the above amount in every hundred pounds of melted iron.

Drilling a Larger Hole through Smaller Hole with Same Drill.

No. 7. With the same drill, say you want to drill a ¾ hole in piece of iron. Now you want the hole 1 in. deep, and 1 inch deeper at bottom and larger at bottom. To make this drill the ¾ hole first 1 inch deep, use a V-shaped drill, then grind the point of same drill ⅛ to one side. Don't grind it smaller and for every ⅛ you grind the point to one side, you will drill the hole twice that size larger. It will drill shoulder where larger hole begins.

Solution to Harden Cast or Gray Iron to Any Degree.

No. 8. 1 Pint Oil of Vitriol.
1 Bushel of Salt.
1 Pound of Saltpeter.
2 Pounds of Alum.
¼ Pound of Prussic Potash.
¼ Pound of Cyanide Potash.

Dissolve the whole in three gallons of rain water. Heat iron to cherry red and cool in solution.

Dressing Mill Pick.

No. 9. To dress mill picks, heat to cherry red and dip points while hot in a tallow before hammering. Then to temper them:

2 Ounces Muriate of Ammonia.
2 Ounces Chloride of Potash.
2 Gallons Soft Water.

Heat to cherry red and plunge in solution. If too hard add more water.

To Harden Steel Rolls.

No. 10. To prevent shrinkage in side and so prevent bursting take three or four hands full of soot and a small hand full of lime in a pail of water. Heat cherry red and cool off in solution.

In tempering cast steel or any steel always use soft water, always dip towards the North, and tempering round steel, dip perpendicular. Always leave steel in water until cold through.

To Prevent Steel from Springing.

No. 11. Have some dry common soda, heat steel to cherry red, then lay hot steel in soda. Hot steel will melt the soda to a liquid. Let it remain till cool. Will find a good temper.

Hammering Cast Steel.

No. 12. We have often seen smiths spoil a chisel or mill pick by hammering it too cold. This will not spoil a thick piece of steel but will a thin piece. Better take another heat.

Tempering Bitts, Blades or Knives without Drawing Temper.

No. 13. 1 Ounce Pulverized Corrosive Sublimate.
2 Ounces Sal Ammoniac.
Two Hands Full of Salt.

Dissolve in six quarts soft water. Heat to cherry red and plunge in solution and do not draw temper. If too strong add more water.

Solution to Temper Steel to Any Degree.

No. 14. 1 Ounce of Blue Vitriol.
1 Ounce Borax.
1 Ounce Prussic Potash.
½ Pint Salt.

Dissolve all in one quart water, then add one gallon raw linseed oil and ½ ounce pulverized charcoal. Heat cherry red. Cool in solution.

Tempering, Hardening, Toughening and Restoring Steel.

No. 15. This formula for compounding the celebrated patented Mergess solution for tempering, toughening, converting low grade cast steel to higher grade and restoring burnt steel. 4 ounces of citric acid in one gallon boiling water, dissolve two minutes, then add 4 ounces of carbonate of iron, stir for a minute. Now let it stand till agitation stops, then add 6 ounces prussiate of potash, 2 ounces of saltpeter. Then make it into 12 gallons of soft water and stir in six pounds rock salt. Solution is ready. Temper same as in water. But for edge tools bring to proper color, heat slowly, dip hot steel in solution once in a while while heating.

Tempering Steel Springs without Springing.

No. 16. Heat to cherry red, then let it cool off itself. Then coat the spring with soot that will arise from burning resin, then heat evenly until the soot disappears, then immerse in linseed oil. Will make fine temper.

Tempering in Bath, Not Fire.

No. 17. For twist drills, taps, dies, small punches or such articles of cast steel you wish to keep straight; take as follows: Equal parts of prussiate of potash and common salt, put them together in an iron pot over fire when it gets to proper temperature. It will boil and become a cherry red. Put the tool in this until it becomes a cherry red. You may leave the tool in all day if you wish, for the longer the more it improves the steel. When you take it out cool in water or linseed oil, always in a vertical position. Do not draw. But for taps or dies draw to dark straw.

To Harden Cast Iron to Cut Glass or Cutting Purposes.

No. 18. 2 pounds Common Salt,
½ pound Saltpeter,
½ pound Rock Alum,
¼ ounce Salts of Tartar,
¼ ounce Cyanide of Potash,
6 ounces Carbonate of Ammonia.

Mix and thoroughly pulverize together. Apply this to surface when the metal is cherry red and plunge in cold, soft water.

Tempering Round Piece Cast Steel without Springing.

No. 19. Stir the water fast with stick. While the water is in a whirl plunge hot steel in center of whirl perpendicular. Water turning around it will keep it straight.

Tempering Drills.

No. 20. Heat to cherry red and plunge in lump of Beeswax and Tallow mixed. Not too much tallow or will make soft.

To Temper a Thin Blade or Knife.

No. 21. Cut a piece of paper a little larger than blade, then heat blade evenly, then lay the paper flat on water, lay blade on paper and press under to cool. Never mind the theory. Try it. Always dip blades to North.

Remarks When Welding Cast Steel or Any Steel.

Always weld the same way. Begin where you left off. Take one heat and the next heat begin where you left off so the dross and scales will work out. If you weld one end then stick the other end the dirt will get in center and can't get out and you can not weld it any way.

Welding Cast Steel with Less Heat.

No. 22. Mix Sal Ammonia with ten times the amount of Borax. Fuse well when pulverized. Now mix with this an equal quantity of quick lime and use as borax.

Welding Steel Bessemer Spring Axles and Tool Steel.

No. 23. 15 pounds Dry Sand,
8 ounces of Powdered Sulphate of Iron,
8 ounces of Black Manganese,
8 ounces Fine Salt. Use as Borax.

Welding Cast Steel and Restoring Burnt Steel.

No. 24. ¾ pound Borax,
¼ pound of Sal Ammonia,
⅛ pound of Prussic Potash,
½ ounce of Resin,
½ gill of Alcohol.

Simmer these in spider over slow fire until well chased. Then use as Borax.

Welding Cast Iron to Steel or Iron. It Will Weld Better than is Generally Known.

No. 25. 1½ pounds of Powdered Copperas,
1 quart Fine Dry Sand,
1 Hand Full of Salt.

Now make the pieces hot and while heating dip them in mixture. Throw some on in fire. When iron and steel are hot and will stand without running, place them quickly together, rub them with piece of steel or old file, drawing soft parts over each other.

Welding Cast Steel Edge Tools or Any Fine Work.

No. 26. This is the best steel welding compound in use today and is known only by a few good smiths: Dragon blood pulverized and mixed with borax until the borax looks a little pink in color. Use as borax.

Welding Steel Boiler Tubes.

No. 27. Flare long piece out, fit short piece inside the other neatly, then lay in fire. When hot enough, sprinkle on welding compound. Have helper tap lightly on end of short piece, while you take light hammer and tap it lightly in fire turning all the time. Weld it all in fire.

Repairing Plows, New Shear and Laying.

No. 28. First take old plow, set it on level board. See that it measures 16 inches from floor to hitch and has 2¼ inches land. If not, while repairing bring it to that, and then it will run right. In laying shears take hammer, lay steel 2 by 5-16 and use the welding compound mentioned above. Don't make wing of shear more than 6½ inches wide. For new shares lay steel for shares on plow, make wing 6½ inches wide, cut off on land side what you don't need. Now bend wing down shape of old. Lay share piece under and weld up.

Stream Tempering All Heavy Tools.

No. 29. We will take a hand hammer for example. Take a can or keg, make a three-eighths inch hole in it; then heat hammer a cherry red; then hold peen in slack tub and let three-eighths stream pour on center of face until cool enough; then let draw to a dark straw color. If it does not draw to right color, heat eye wedge put in hole until the right colors appear. The old way of dipping in tub cools outside too fast, cracks it and makes it shelly. The new way of cooling center the fastest contracts the steel and makes it solid, and it will never crack nor sprall off.

Redressing and Tempering Old Anvils.

No. 30. Heat old anvil to draw temper; let it cool slow, plane off face, heat face to cherry red and while hot throw on face a handful of prussiate potash. Then cool as fast as possible with a heavy stream on center of face. It will be as good as a new anvil.

Oil Tempering All Heavy Bolts, Blades and Knives.

No. 31. Heat all flat pieces, knives, blades and bitts on edge. If you lay them flat on fire you will spring them. Heat to cherry red and plunge in raw linseed oil. When cool scour off edge bright. Heat a heavy iron, lay tool on, edge up, draw to dark straw color.

Tallow Tempering for Machinists, Tools and Tools Requiring Hard, Tough Edge.

No. 32. Two-thirds tallow and one-third beeswax; add to this a little saltpeter to toughen steel. Dissolve all and mix. Heat point of tool cherry red; dip point of tool in solution as you would in water and let it draw only to a light straw color. This is a good thing. It improves the steel; all tools will have a hard, tough edge.

Case Hardening Steel Plow Mold Boards.

No. 33. Make a brine of salt and rain water to hold up an egg: add a little saltpeter. Heat steel or mold board cherry red, and while hot sprinkle on face prussiate potash and plunge toward the north in the brine. Let it lay in the brine until cool through and it will not spring nor crack.

Bending Gas Pipe without Breaking.

No. 34. Heat pipe good red heat. If heat is too long, cool off pipe to where you want the bend. Then put end of pipe in fork on anvil, and while bending let helper pour a small stream of water on inside of bend where it looks like kinking. You can bend any shape this way.

Brazing with Copper or Brass.

No. 35. Scarf the ends of pieces so they fit nice. Then clamp the pieces so they fit nice and can not slip. Then lay on fire; put on top side the copper that you think is necessary, and then put on some charred borax or Monarch Welding Compound. Then heat iron until the copper melts. Take a file and keep the copper where you want it, and then lay it down and let cool. This way you can braze iron, steel or malleable iron.

How to Weld Cast Steel with Borax.

No. 36. Put borax in a pot on a slow fire and boil it until it becomes dry like dust: Stir it all the time it is cooking. Then use the dust. You will find it welds much better, as cooking it takes the sulphur out of it, and you will get a clear fire and a nice clean heat.

How to Weld Anything Likely to Slip.

Such as steel tires, but not good for cast steel.

No. 37. To one pound of pulverized borax add two ounces of sal ammoniac. Put a little on tire cold, and when it gets hot it will get very sticky and hold the tire in place so you can handle it. When the tire gets hot put on more. Weld at a borax heat.

Welding or Soldering Band Saws.

No. 38. File scarfs so they fit together nicely; then put a piece of silver solder between laps, or a silver coin will do. Then put on some muriatic acid, or some charred borax is just as good. Then heat a pair of very heavy jawed tongs; heat to a very high heat; hold laps of saw between jaws of tongs until welded. They weld very quick, and will not break where welded. Some pour water on tongs to cool them off fast.

How to Work Self-Hardening Steel (Called Mushet Steel).

No. 39. Heat to cherry red; forge to desired shape; then heat again to cherry red; lay in air to cool—the more air the harder it will be. To make very hard, hold in cold blast.

Instructions for Tempering Pneumatic Tools.

And for some heavy shear knives where it does not require too hard a temper.

No. 40. Heat tool all over; heat very slowly, so it will heat through to cherry red, and plunge tool in linseed oil and let it lay in oil until it is cool clear through. This will give a good temper on any tool required hard all over.

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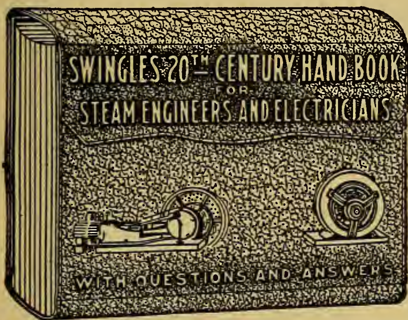

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